South Fork Coquille Watershed Action Plan

Coquille Watershed Association

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Final

Prepared by the South Fork Coquille Technical Advisory Committee

Editor/Writer

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This action plan is dedicated *in memoriam* to Kristle Warren-Volin. Kristle's vision and dedication to the South Fork Coquille River was instrumental in producing the Inter-Fluve, Inc. report and this action plan. Kristle's vision for the South Fork was that the watershed condition, fish populations, and water quality to be returned to good health.

Kristle at the South Fork Coquille River below the Daphne Grove Campground

Contents

List of Tables and Figures

Tables

Figures

Note: Tables and Figures in Appendices are listed in the Table of Contents of the Appendices

Acronyms

303(d)	Clean Water Act, Section 303(d), which requires the development of lists of impaired waters
401	Clean Water Act, Section 401, Water Quality Certification for Federal Actions
404	Clean Water Act, Section 404, Fill and Removal
ACOE	US Army Corp of Engineers
ACS	Aquatic Conservation Strategy
ADFG	Alaska Department of Fish and Game
BACT	Bacteria
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
BSDD	Beaver Slough Drainage District
CFS	Cubic Feet per Second
CIS	Commission on Indian Services
CREP	Conservation Reserve Enhancement Program
CW	Coarse Wood
CWA	Coquille Watershed Association
CWEP	Clean Water Education Partnership
DBH	Diameter Breast Height
D/S	Downstream
DEQ	Oregon Department of Environmental Quality
DO	Dissolved Oxygen
DOGAMI	Oregon Department of Geology and Mineral Industries
DPS	Distinct Population Segments
DSL	Oregon Department of State Lands
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
FEMA	Federal Emergency Management Agency
FWS	Fall, Winter, Spring (October – May)

GLO	General Land Office
GWEB	Governor’s Watershed Enhancement Board
HUA	Human Use Allowance
HUC	Hydrologic Unit Codes
LRMP	Land and Resource Management Plan
LW	Large Wood
MCL	Maximum Allowable Contaminant Level
MWCF	Marine Western Coastal Forest
N	Nitrogen
NEPA	National Environmental Policy Act
NFS	National Forest Service
NMFS	National Marine Fisheries Services
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resource Conservation Service
NTU	Nephelometric Turbidity Units
NWFP	Northwest Forest Plan
NWP	Nationwide Permit
OAR	Oregon Administrative Rules
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OHD	Oregon Health Division
OHW	Ordinary High Water
OPSW	Oregon Plan for Salmon and Watersheds
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
OWQI	Oregon Water Quality Index
OWRD	Oregon Water Resources Department
OWRI	Oregon Watershed Restoration Inventory
P	Phosphorus
PVC	Poly Vinyl Chloride
RGP	Regional General Permit
RM	River Mile
RMP	Resource Management Plan

RRSNF	Rogue River-Siskiyou National Forest
SDWIS	Safe Drinking Water Information System
SFC	South Fork Coquille
SHPO	Oregon State Historic Preservation Office
SMU	Species Management Unit
STP	Sewage Treatment Plant
SWCD	Coos Soil and Water Conservation District
T	Temperature
T & E	Threatened and Endangered
TEA	Transportation Equity Act
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TS	Total Solids
Type D	Streams utilized as Drinking Water Sources as per Oregon Forest Practices Act
Type F	Fish Bearing Streams as per Oregon Forest Practices Act
Type N	Non-Fish Bearing Streams as per Oregon Forest Practices Act
U/S	Upstream
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Services
USGCRP	United States Global Change Research Program
USGS	United States Geological Survey
USU	Utah State University
WAB	Water Availability Basins
WDOE	Washington Department of Ecology
WQC	Water Quality Certification
WQMP	Water Quality Management Plan
WWRI	Whole Watershed Restoration Initiative

Introduction

This Action Plan is written by the South Fork Coquille Technical Advisory Committee of the Coquille Watershed Association in cooperation with several federal, state, local, and private entities (see list of contributors). The purpose of this plan is to present a summary of information about the South Fork Coquille River Watershed and formulate an Action Plan based on all available scientific information. This information includes a recent report by Inter-Fluve, Inc. (2013) commissioned by the that the Coquille Watershed Association to fill in gaps of knowledge on the watershed needed in order to complete this Action Plan.

There have been many previous studies regarding the South Fork Coquille River in recent history. Florsheim and Williams (1995) analyzed river mile (RM) 5-10. Later, Clearwater BioStudies, Inc. (2003) analyzed the lowest 34.7 miles of the river and three tributaries (Dement, Hayes, and Yellow Creeks), while utilizing information in Florsheim and Williams (1995). The Inter-Fluve, Inc. (2013) report utilized information from these reports and further analyzed the river from the mouth to the headwaters, just upstream of Foggy Creek, which is 60.4 river miles. While Inter-Fluve, Inc. (2013) was completing their report, a USGS report of the river (Jones et al., 2012) was released. Jones et al. (2012) analyzes channel stability and bed-material transport of the South Fork Coquille River covering the same portion of the river as Clearwater BioStudies, Inc. (2003). In addition, the federal land management agencies completed watershed analyses for lands managed by the USFS and BLM in the South Fork Coquille Watershed (USDA USFS, 1995 and USDI BLM, 1996). The USFS also completed an Aquatic Restoration Plan of the South Fork Coquille Watershed in 2007 (USDA USFS, 2007). This Action Plan utilizes information from all of these reports to formulate a coordinated restoration approach to the South Fork Coquille River and its tributaries.

This Action Plan will provide an overview of the watershed (Chapter 1), describe aquatic habitat limiting factors with a historical context (Chapter 2), describe past restoration efforts (Chapter 3), provide an overview of the geomorphic and hydrologic characteristics of the river and tributaries (Chapter 4), present a restoration approach to the river and tributaries (Chapter 5), and present recommended restoration design methods (Chapter 6).

Chapter 1: Watershed Overview – Defining River Dynamics

1.1 Watershed Overview

The South Fork Coquille River is a large fifth-order stream located in southern Coos County within the Southwest region of Oregon (Figure 1-1). The river generally flows south to north from an alluvial flat known as Eden Valley through Powers, Oregon to Myrtle Point, Oregon where it joins the Middle and North Fork Coquille Rivers flowing into the Pacific Ocean near Bandon, Oregon. The South Fork Coquille River is the longest fork in the Coquille Subbasin consisting of 63 stream miles with a drainage size of approximately 283 square miles (Inter-Fluve, Inc., 2013).   By comparison, the Middle Fork Coquille River has a drainage area of 310 square miles (Inter-Fluve, Inc., 2013). The geology of the South Fork Coquille River uniquely changes from the steep rocky headwaters above the city of Powers to a low gradient (<1%), incised, alluvial channel. The change in geology and channel morphology results in stable headwaters and an unstable lower stream channel.   The Middle Fork Coquille River enters the South Fork 4.7 miles from the mouth of the South Fork Coquille River. In this document, discussion of the South Fork Coquille River does not include the Middle Fork, though its effects are evident in the lowest portion of the South Fork below their confluence.

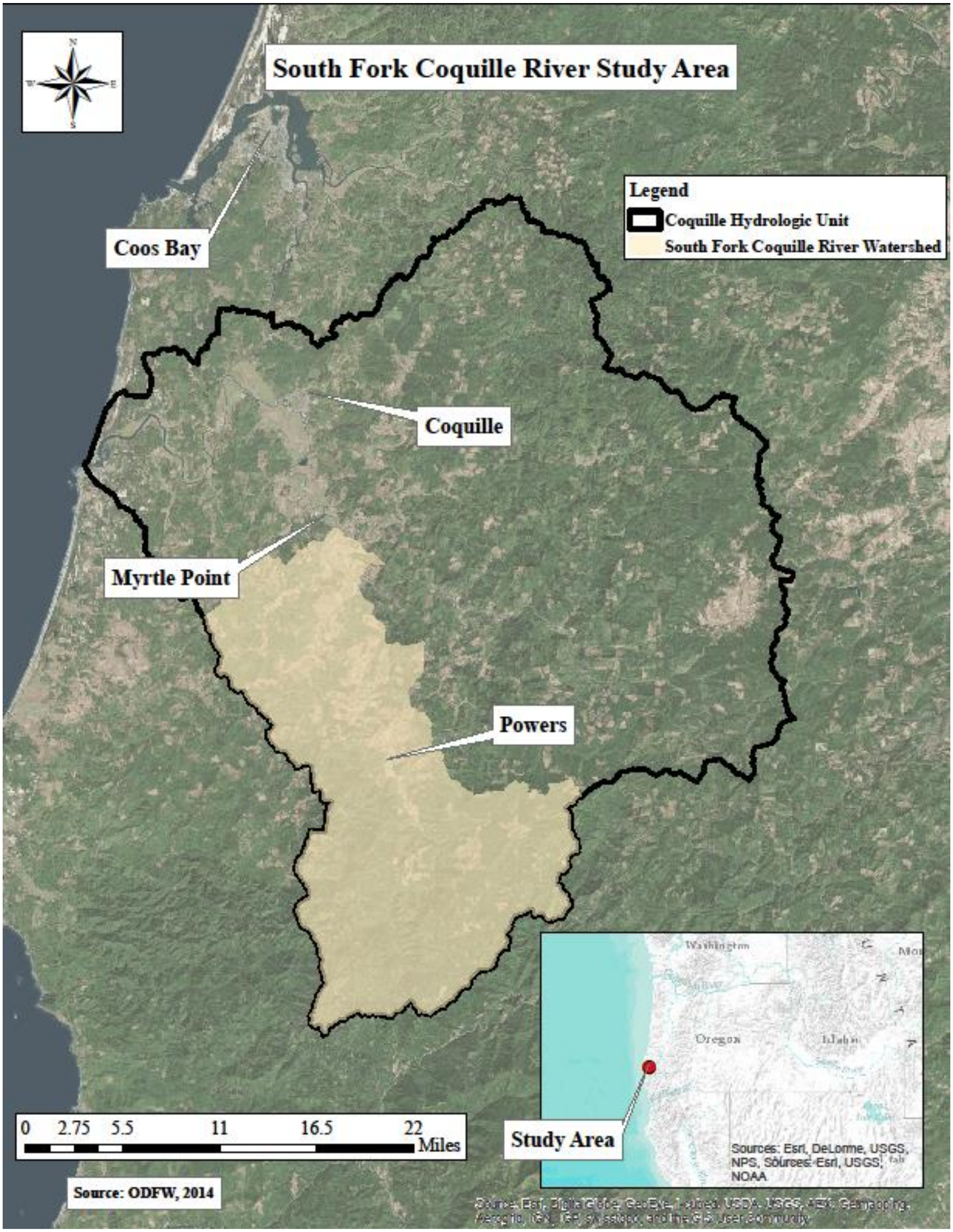

Figure 1- 1. South Fork Coquille River Watershed within the Coquille Subbasin.

The headwaters of the South Fork Coquille River lie in the northwestern corner of the Klamath Mountain Province, which is active due to the climate and tectonic setting resulting from the convergence of the Juan de Fuca and North American plates (Florsheim and Williams, 1995). The remainder of the watershed lies in the southern part of the Coast Range Province, which consists of uplifted sedimentary and volcanic rocks (Florsheim and Williams, 1995). Due to fluctuating sea levels and continual uplifting and infilling the South Fork Coquille River has created alluvial sediment deposition and terraces such as the one that the city of Myrtle Point occupies. Both of these geologies produce fine grain sediments which are transported to stream channels. Descriptions of the geology of the watershed can be found in Figure 1-2. Erosion of the rugged hillslopes of the South Fork Coquille Watershed is the primary source of sediment (Florsheim and Williams, 1995).

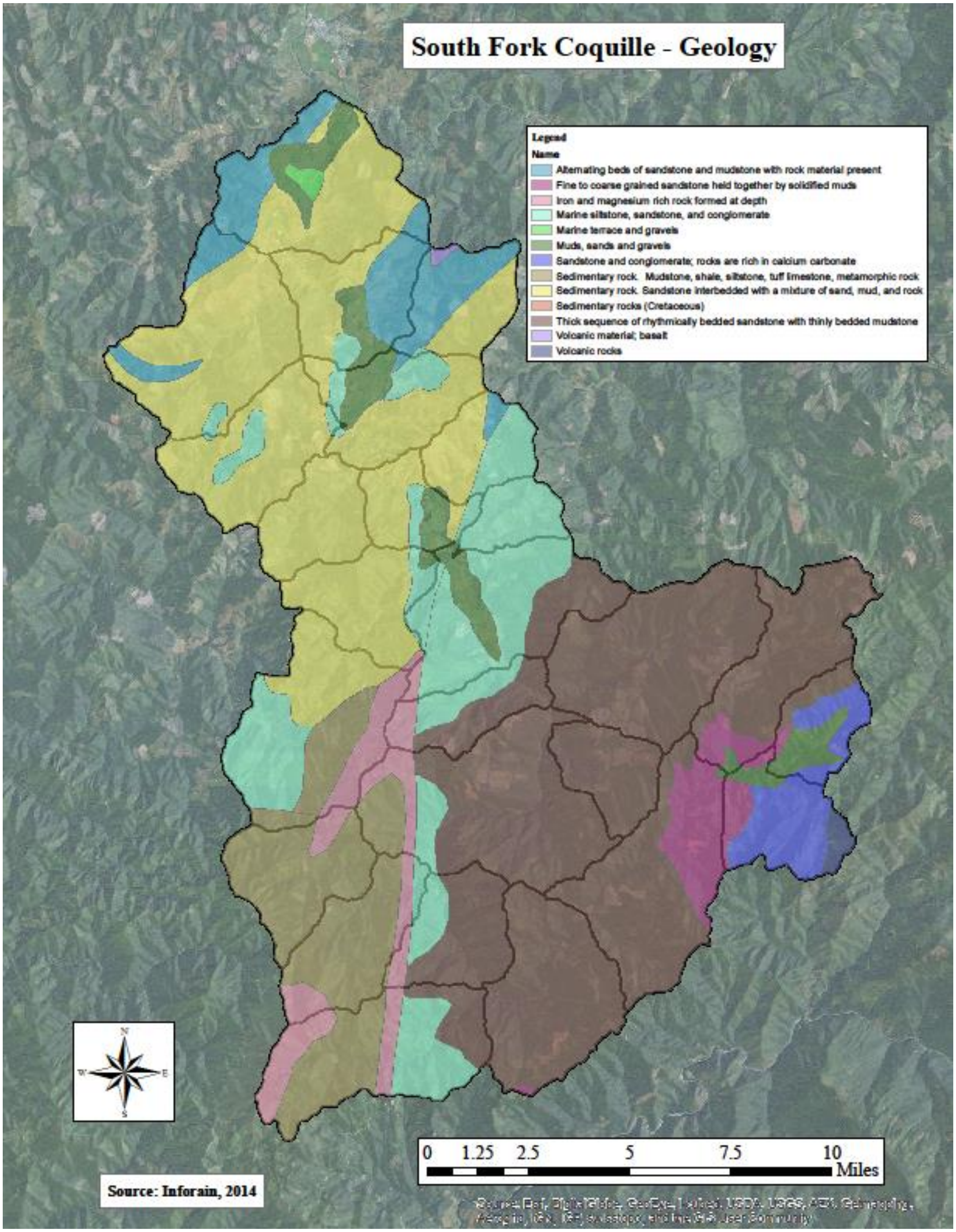

Figure 1- 2. Geology of the South Fork Coquille Watershed (Walker and MacLeod, 1991).

The South Fork Coquille River is divided into the upper and lower portion primarily due to the differences in channel morphology and ownership. Though there is a small portion of private ownership (Figure 1-3), the Upper South Fork Coquille River is primarily managed by the United States Forest Service (USFS) (Figure 1-3) and located within the Rogue River-Siskiyou National Forest (RRSNF). The RRSNF was established in 1905 first as the Siskiyou Forest Reserve, later the Siskiyou National Forest, and most recently changed its name to the Rogue River-Siskiyou National Forest when it combined with the Rogue River National Forest in 2004. The USFS manages 61% of the land within the 108,300 acre South Fork Coquille Watershed (USDA USFS, 2007). The lower South Fork Coquille River primarily has private ownership and federal ownership managed by the Bureau of Land Management (BLM) with a small portion of land (309 acres) managed by the Bureau of Indian Affairs (BIA) in T30S R11W Sec 7 and T30S R12W Sec. 12 (Figure 1-3).

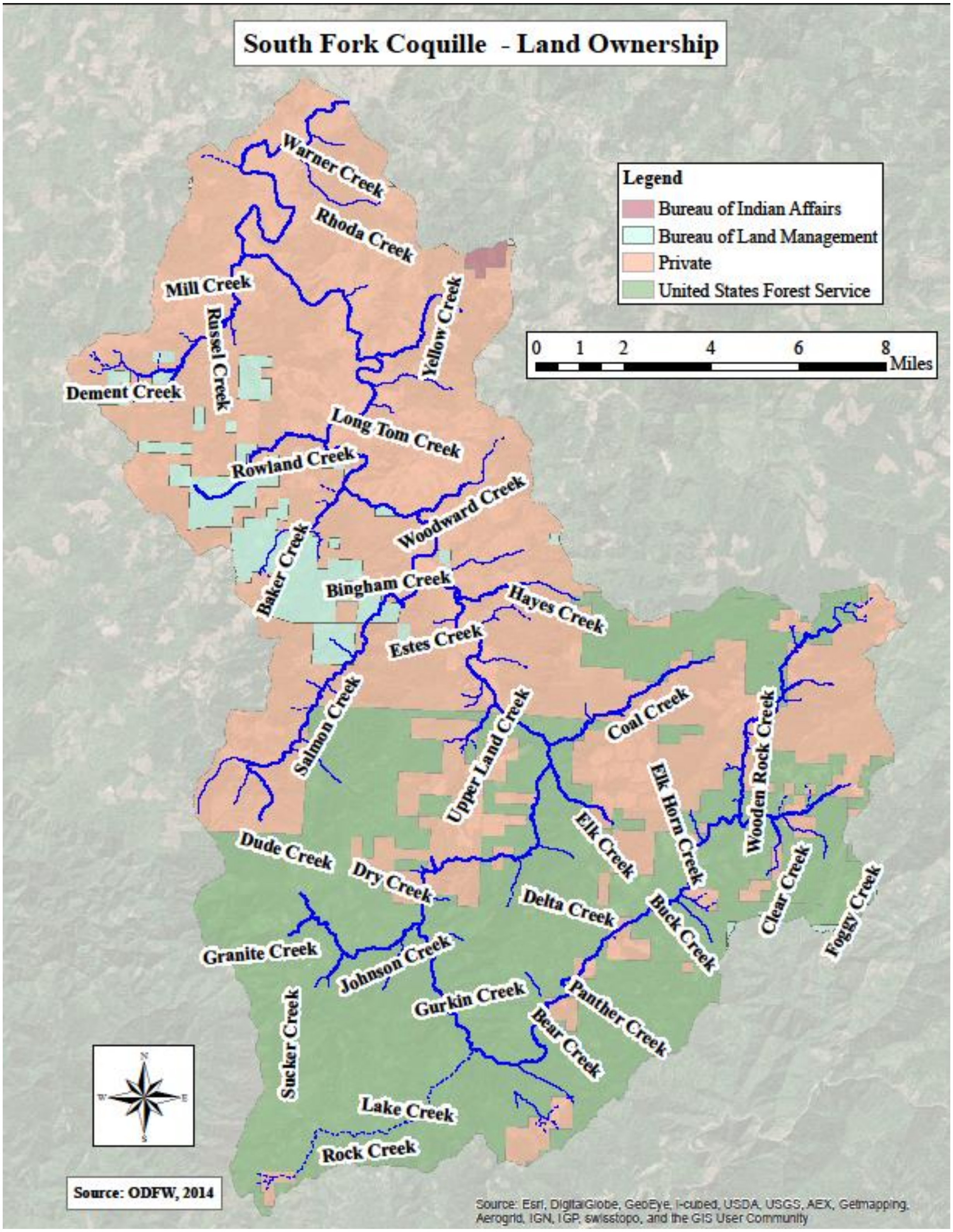

Figure 1- 3. South Fork Coquille Watershed ownership.

While the Coquille River is considered navigable by the State of Oregon up to the confluence of the North and South Forks, the South Fork of the Coquille River is not considered navigable and therefore it is not owned by the State (Oregon Department of State Lands (DSL), 2014).

The upper portion first flows southwest, paralleling the Rogue River and then sharply turns north around Eden Ridge slicing through the Klamath Mountains. This portion of the river is steeply incised occasionally dropping over 80 meters within one kilometer. It is heavily forested with species such as Douglas fir, Western red cedar, Western hemlock, and red alder (see Appendix A for scientific names). The terrain is interspersed with valuable minerals and rocks including serpentine, crypto-crystalline silicate, schist, coal, and gold.

The lower South Fork Coquille River (from the forest boundary to the city of Myrtle Point) is 34.7 miles long and contains 65,669 acres. This portion of the watershed is a low gradient (average elevation change of 47 feet/mile), wide alluvial channel, with large gravel bar deposits and is extremely incised. Pleistocene- or Holocene-age alluvial sediments often tower 20 meters above the river. Approximately 18% of this area is federally owned with 82% privately owned. As the South Fork Coquille River formed over time it deposited rich soils creating a wide floodplain. As a result, highly productive lands were created and are privately owned for agricultural use.

1.2 Climate

The South Fork Coquille River is dominated by a wet, warm, marine climate with temperature variation that has a strong correlation to change in elevation. Precipitation occurs primarily as rainfall but fog may contribute to the average annual precipitation of 55 inches near Gaylord to over 120 inches in a year in the upper elevations (USDI BLM, 1996) Close to 80% of the average annual precipitation occurs between October and March, with 50% occurring during November - January (USDI BLM, 1996). A snowpack is present at elevations ranging from 300 feet (city of Powers) – 2,000 feet. Annual snowfall ranges from 3 inches to 40+ inches in the higher elevations (USDI BLM, 1996). These snowpacks are typically intermittent, persisting on the ground for only a few weeks (USDI BLM, 1996). High precipitation exacerbates runoff, flooding, erosion and slides or debris torrents within the watershed. Climate change and its associated effects will be discussed in Chapter 2.

Pineapple Express

A pineapple express is the name for a meteorological phenomenon defined by a strong and steady flow of moisture and typified by heavy precipitation (Dettinger, 2004). Heavy rainfall can extend from the Pacific Ocean near the Hawaiian Islands to any location along the Pacific Coast of North America (Dettinger, 2004). A pineapple express is an example of an atmospheric river, or a relatively narrow band of concentrated moisture that forms between large areas of opposing surface air flow (NOAA, 2014). It leads to warm wet weather along the Pacific Coast (Dettinger, 2014). If pineapple express events can follow snow events, they can lead to major snow-melt flooding with warm air and heavy rains falling on snow-covered ground (Dettinger, 2004). Examples of major pineapple express-driven flood events have occurred in the Coquille Valley in December 1964 and January 1968 (NOAA NWS, 2014).

Climate Change

Climate change is a slow ongoing process. Climate models have shown that the average annual temperature rose by 1.5°F, with increases in some areas up to 4°F over the last century in the northwest (Karl et al., 2009). Average annual temperature is projected to increase by 3-10°F by the end of the 21st century. Winter precipitation is projected to increase while summer precipitation is projected to decrease. However, precipitation projections are less certain than those related to temperature (Karl et al., 2009).

Specific meteorological and concurrent watershed changes (Karl et al., 2009) may include:

- More precipitation may fall as rain instead of snow and this would decrease snow accumulation, particularly in the rain-on-snow elevations. Snowpack (measured on April 1st) as an indicator of natural water storage available for the warm season, is projected to decline by as much as 40% in the Cascades by 2040.
- Timing of spring runoff may shift earlier, by as much as 20-40 days by the 22nd century.
- More precipitation may fall as rain and winter precipitation is expected to increase with associated increased flood risks.
- This reduction in available snowpack (and thus water) could increase the risk of drought during normally dry summers. However, coastal watersheds, such as the South Fork Coquille, that receive little snow accumulation should not be impacted by loss of water storage as snow. Further, it is more uncertain if summer precipitation will remain low or increase from a normally dry season. Increases in summer precipitation may be beneficial for water quality and fisheries resources in the Coast Range.

Early in 2014, a climate change study for the Coquille River was completed: the Coquille Estuary Climate Change Vulnerability Assessment (Mielbrecht et al., 2014). The goal was to provide information on habitats and species in the Coquille estuaries related to climate change and also to provide a template for conducting inexpensive vulnerability assessments for estuaries and riparian areas of small coastal watersheds (Mielbrecht et al., 2014).

1.3 Fish Species, Life History, Distribution

The South Fork Coquille River is designated a Tier 1 Key Watershed in the Siskiyou Land and Resource Management Plan (USDA USFS, 1989) and the Coos Bay BLM Resource Management Plan (USDI BLM, 1995). A Tier 1 Key Watershed "…contributes directly to conservation of at-risk anadromous salmonids, Bull Trout, and resident fish species… with high potential of being restored as part of a watershed restoration program" (USDI BLM, 1995). The South Fork Coquille River consists of 27% of the entire Coquille Subbasin, with approximately 22% of the fish habitat for the Coquille Subbasin (ODFW, 2014). The primary species found in this watershed are included in Table 1-1.

Table 1- 1. Fish species present in the South Fork Coquille River Watershed.

Common Name	Scientific Name
Native Species	
Chinook Salmon	*Oncorhynchus tschawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Winter Steelhead Trout	*Oncorhynchus mykiss*
Cutthroat Trout (Resident and Sea-Run)	*Oncorhynchus clarki clarki*
Rainbow Trout (Resident)	*Oncorhynchus mykiss*
Pacific Lamprey	*Entosphenus tridentatus*
Western Brook Lamprey	*Lampetra richardsoni*
Sculpin species	*Cottidae family*
Large scale Sucker	*Catostamus macrocheilus*
Speckled Dace	*Rhinichthys osculus*
Non-Native Species	
Smallmouth Bass	*Micropterus dolomieu*
Largemouth Bass	*Micropterus salmonides*
Striped Bass	*Morone saxatilis*
Catfish species	*Ictalurus spp.*

Salmon and trout are commonly referred to collectively as salmonids. The focal species for this action plan and future restoration are fall Chinook Salmon, Coho Salmon, winter steelhead, Cutthroat Trout, and Pacific Lamprey.

The major tributaries to the South Fork Coquille River and their size according to OAR 629-635-0200 are located in Figure 1-4. These sizes relate to different streamside buffers required under the Oregon Forest Practices Act (see Section 1.4.c. for more information). The DEQ Fish Use Designations (Figure 1-5) and Salmon and Steelhead Spawning Use Map (Figure 1-6) are also included.

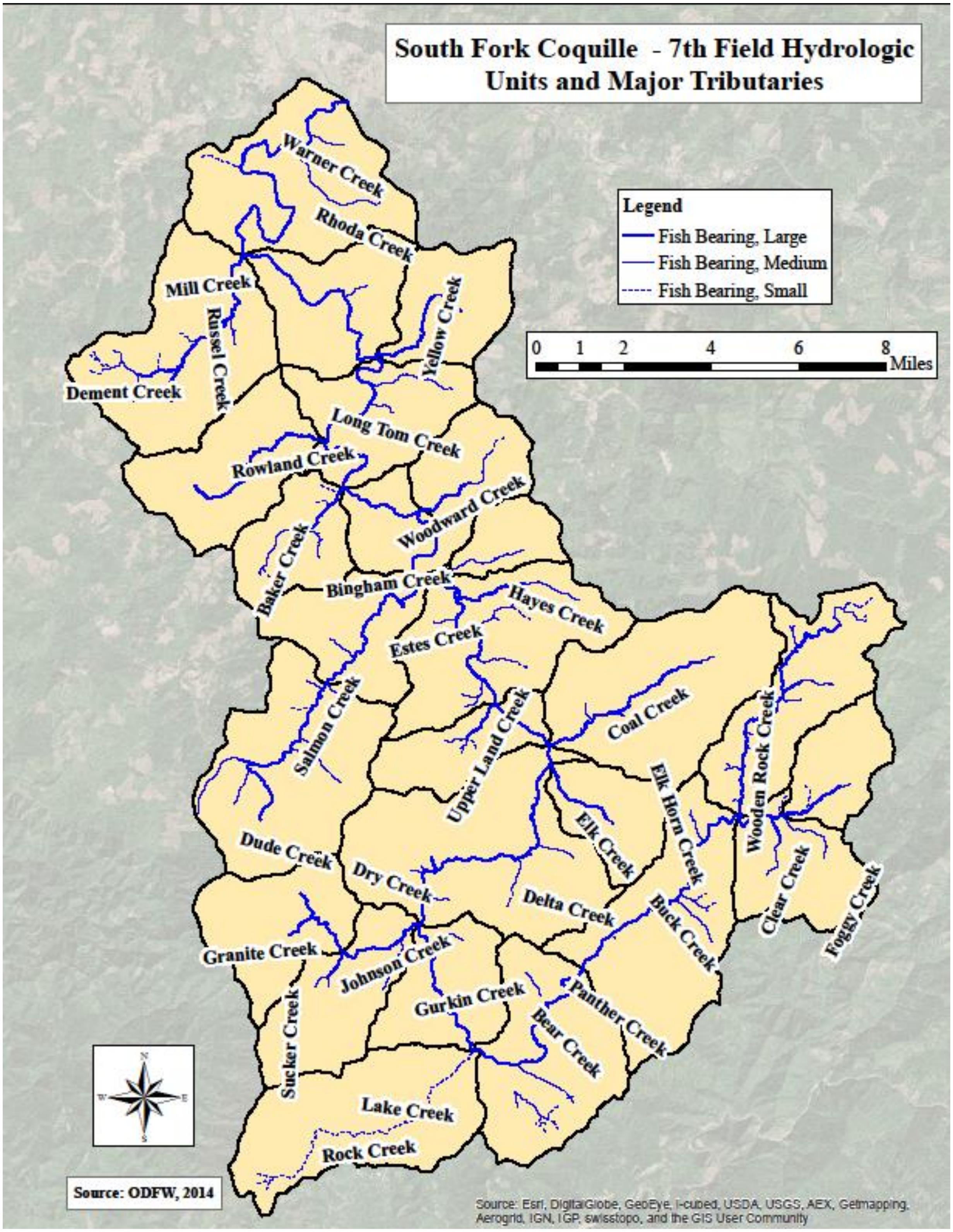

Figure 1- 4. Seventh field hydrologic units and major tributaries showing small, medium, and large fish bearing streams (OAR 629-635-0200).

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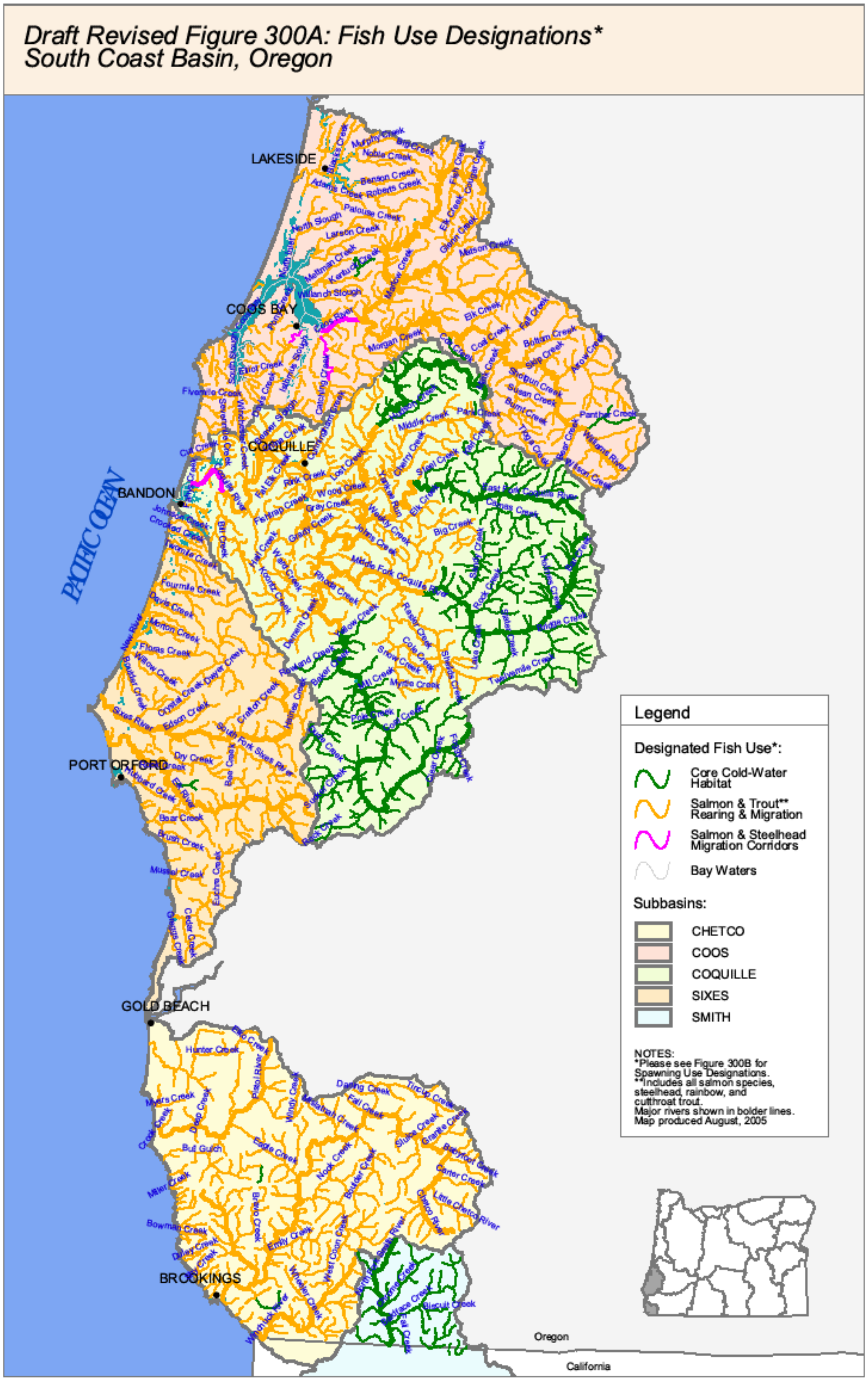


Figure 1- 5. South Coast Fish Use Map (Figure 300A in DEQ, 2005a).

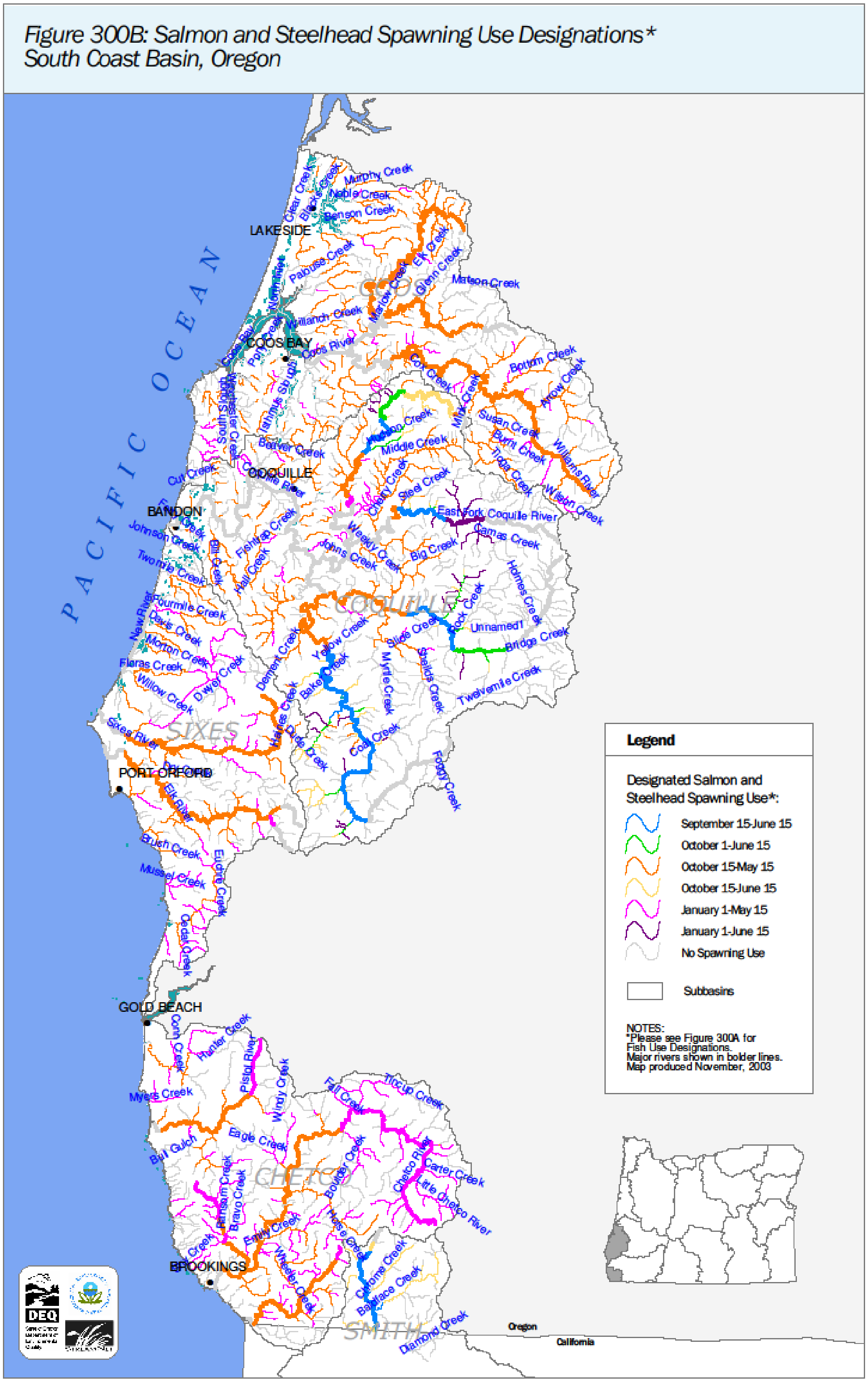


Figure 1- 6. South Coast Salmon and Steelhead Spawning Use Map (Figure 300B in DEQ, 2003a).

1.3.a. Salmon life cycle

Anadromous species within the Salmonidae family typically exhibit the same general life cycle (Figure 1-7) with differences in timing, habitat preference, and rearing length.

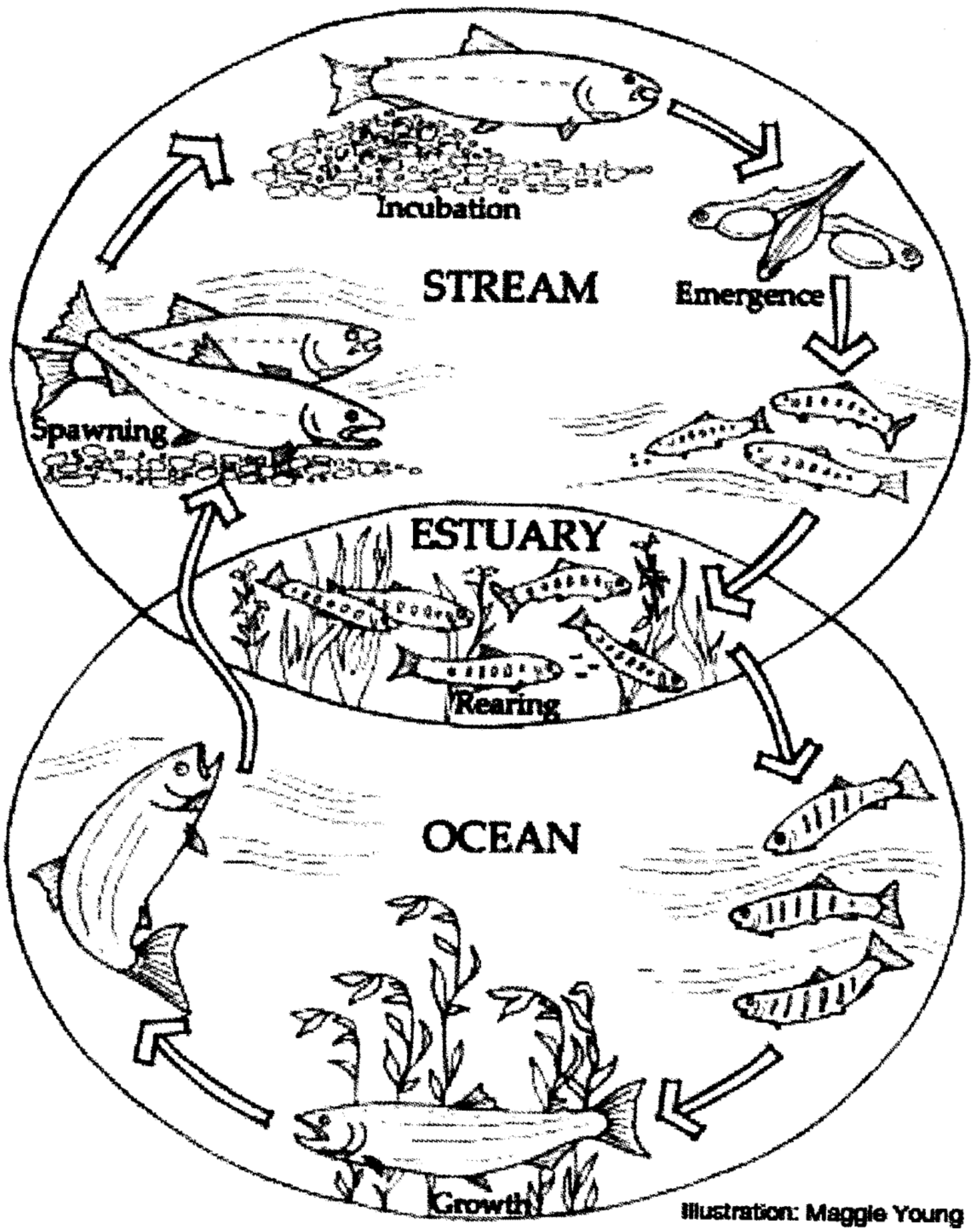


Figure 1- 7. Illustration of the salmon life cycle (Young, 2014).

Adult salmon migrate to their natal stream from ages two to six years old during fall and winter months utilizing their strong homing system. Timing for upstream migration is dependent on stream flow and temperatures but typically occurs from October - February. Male salmon will often change coloration and jaw shape for spawning displays and defense. After a long journey to suitable spawning habitat, the males stand guard utilizing their gnarled jaw and teeth to ward off others as the females dig a nest (known as redds) in the gravel utilizing sweeping movements of her tail. Adult male and female salmon simultaneously release their eggs and milt (sperm) into the redd. Adult females lay 2,000 – 5,000 eggs. After a few weeks most adult salmon, except steelhead, will perish significantly contributing to the nutrient cycle. The fertilized eggs hatch and become alevin with a yolk sac attached providing rich nutrients. Alevins are incapable of swimming and must depend on their ability to hide in the streambed gravel. During this stage they are extremely vulnerable to predation. As the yolk sac dissipates the young alevins emerge from the gravel as a one inch fry and start actively searching for food. When a fry reaches approximately two inches it is called a parr and starts to develop distinctive vertical bars (parr marks) on their sides to camouflage them. Salmon will remain parr for a few months to a year depending on the species. During this rearing phase, juvenile salmon will disperse to suitable habitat based on desired attributes for each species. After a period of growth, juvenile salmon will migrate downstream towards the ocean. A series of physiological and morphological changes will occur as the juvenile salmon acclimates to salt water conditions during the smolt phase. Once in the ocean, the smolts will feed and develop into fully mature adult salmon.

<u>1.3.b. Focal Fish Species</u>

Coho Salmon (*Oncorhynchus kisutch*)

The Coquille Subbasin Coho Salmon is a functionally independent population within the Oregon Coastal Coho Evolutionary Significant Unit (ESU). Historically, the Coquille Subbasin supported a large and healthy wild population of Coho Salmon estimated to have been as high as 400,000 dependent on the year. Cannery records documented 30,000 – 50,000 Coho packed per year between 1892 and 1922, which represent at best half of the annual river runs (Benner, 1991). Currently the Oregon Coast Coho is listed as threatened under the Endangered Species Act. Harvest rates have remained incidental harvest in the Chinook fishery since 1994. In 2007, the Oregon Coast Coho Conservation Plan established benchmarks or “measurable criteria” for abundance, persistence, productivity, distribution and diversity of Oregon Coast Coho population including the Coquille Coho population (ODFW, 2007 and Table 1-2). Coho are a key indicator of ecological health as the biological and physical processes that form and sustain required Coho habitat are the same processes affecting Chinook Salmon, lamprey, and other native fishes.

Table 1- 2. The Oregon Coast Coho Conservation Plan benchmarks for the Coquille Coho Population (ODFW, 2007).

Evolutionary Significant Unit	Independent Population	Spawning Year	Abundance			Productivity		Distribution		Juvenile Habitat	
			Observed	Goal	Proportion of Goal Achieved	Observed Recruitment - Spawning Ratio	Recuitment - Spawning Ration Goal	Proportion Occupied	Occupancy Goal	Existing Stream Miles	Stream Miles Goal
Oregon Coast	Coquille	1994	5,119	8,400	0.61	1.27	1				
Oregon Coast	Coquille	1995	2,034	8,400	0.24	1.24	1				
Oregon Coast	Coquille	1996	15,814	8,400	1.88	0.18	0.9				
Oregon Coast	Coquille	1997	5,720	8,400	0.68	1.18	1				
Oregon Coast	Coquille	1998	2,412	8,400	0.29	6.17	1	0.5	0.78		
Oregon Coast	Coquille	1999	2,667	30,900	0.09	3.27	1	0.54	0.85		
Oregon Coast	Coquille	2000	6,253	30,900	0.20	4.17	1	0.63	0.85		
Oregon Coast	Coquille	2001	13,833	59,500	0.23	1.66	1	0.7	0.85		
Oregon Coast	Coquille	2002	7,676	30,900	0.25	1.69	1	0.64	0.85		
Oregon Coast	Coquille	2003	22,403	59,500	0.38	1.35	1	0.93	0.85		
Oregon Coast	Coquille	2004	22,138	59,500	0.37	0.71	1	0.87	0.85		
Oregon Coast	Coquille	2005	11,806	30,900	0.38	0.86	1	1	0.85		
Oregon Coast	Coquille	2006	28,577	30,900	0.93	0.87	1	0.86	0.85		
Oregon Coast	Coquille	2007	13,968	59,500	0.24	1.83	1	0.67	0.85	148.7	321
Oregon Coast	Coquille	2008	8,791	8,400	1.05			0.75	0.78		
Oregon Coast	Coquille	2009	22,286	59,500	0.38			0.92	0.85		
Oregon Coast	Coquille	2010	23,564	30,900	0.76			0.88	0.85		

Standard Oregon Department of Fish and Wildlife spawning surveys show an increase in wild/natural Coho escapement in the Coquille River (Figure 1-8). From 1990–2009 Coho returns averaged 10,602 adults annually, which are considered to be roughly 10% of the historical annual average.

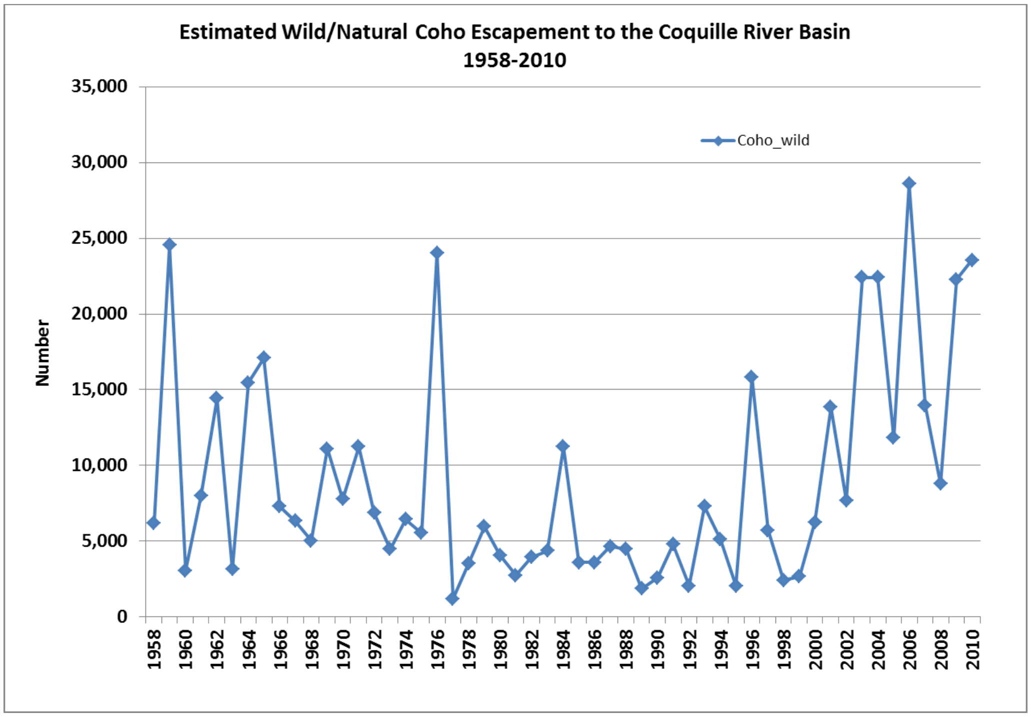


Figure 1- 8. ODFW wild/natural Coho Salmon escapement in the Coquille River Subbasin from 1958-2010.

The South Fork Coquille River is important for late fall and winter rearing of Coho juveniles that are migrating from tributaries in October and November as temperatures decrease. Juveniles typically spend one summer and one winter in fresh water before migrating to the ocean. During rearing, complex pools, off-channel habitat and slow water refugia provide are essential. The exact percentage of overwintering Coho juveniles that move into large streams is unknown. However, some percentage remains in the South Fork Coquille River tributaries like Dement Creek until March. When Coho begin migration toward the ocean, a large percentage moves into the mainstem reaches and accessible wetlands.

Chinook Salmon (*Oncorhynchus tshawytscha*)

The Coquille Chinook Salmon population is within the Oregon Coast Evolutionary Significant Unit (ESU), but is not an ESA listed population. Cannery records documented 1,000 – 8,000 Chinook Salmon packed per year between 1892 and 1922, which represent at best half of the annual run size (Benner, 1991). Chinook Salmon are the largest species of salmon within the Coquille Subbasin, with adults averaging between 20-30 pounds. Chinook Salmon exhibit a wide range of life history during ocean entry; ocean migration patterns; and adult migration, habitat selection, spawning, and age/size at maturity (CWA, 1997).

The South Fork Coquille River is a gravel-rich system offering highly valuable spawning and early life rearing habitat of Chinook Salmon. Approximately 60% of the Coquille wild/natural Chinook spawn in the South Fork Coquille River (Christopher Claire, ODFW, personal communication). Spring Chinook typically enter the South Fork Coquille River between June and August where spawning has been observed from Rowland Creek (apx. RM 23.5) to Daphne Grove (RM 22.8). Fall Chinook enter the South Fork Coquille River after the first significant rain from October through December. Chinook usually spawn in the larger streams requiring deep holding pools and cold thermal refugia during upstream migration. Elevated summer temperatures, low flows and the loss of deep holes are habitat limiting factors that can suppress Chinook production in the South Fork Coquille River.

A Chinook hatchery program has been in effect since 1984 on the Coquille River to supplement runs. Bingham Creek, off the South Fork Coquille River near the city of Powers, is a hatchery release site for unfed fall Chinook fry. This program has been successful at supplementing the existing population. There has been significant increase in wild/natural fall Chinook Salmon escapement since 1958 (Figure 1-9).

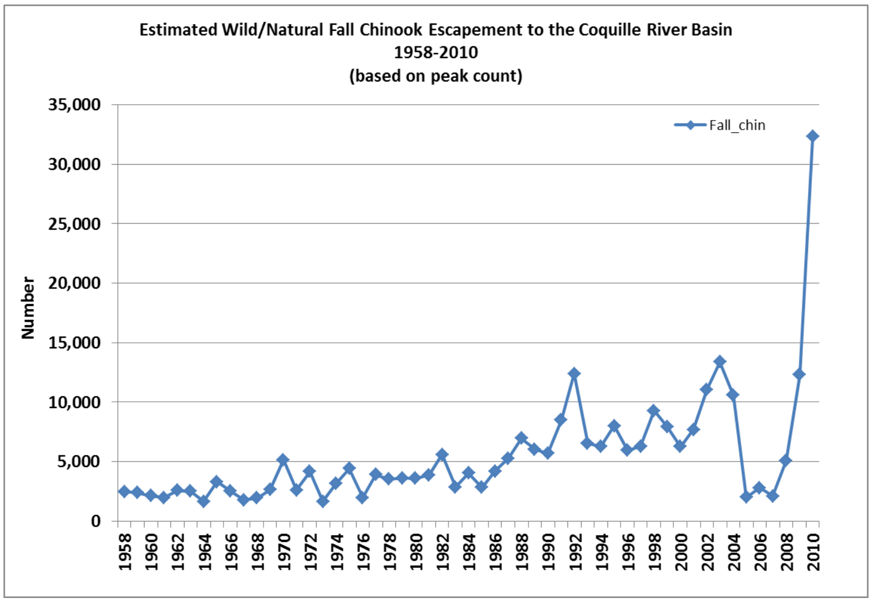


Figure 1- 9. ODFW wild/natural fall Chinook escapement in the Coquille River Subbasin from 1958-2010.

Spring Chinook

Spring Chinook enter the South Fork of the Coquille from April through July, where they spend the summer holding in deep pools. Spawning coincides with the onset of the first fall rains. Spring Chinook have been observed spawning in the South Fork Coquille River from the confluence of Rowland Creek upstream to Rock Creek (USDI BLM, 1996). Fry emerge from redds from February to May, depending on water temperature. Presmolts outmigrate toward the estuary through the summer months and into the fall. They typically spend three to five years in the ocean before returning to their natal streams to spawn.

Because of their large body size, Chinook Salmon require greater water depths for upstream migration and holding, compared with other Pacific salmon. The requirement for holding pools is especially critical for spring Chinook, which may be in fresh water from 4 to 6 months during summer low flow conditions prior to spawning (Nickelson et al., 1992). If holding and spawning areas have inadequate cover, spring Chinook are vulnerable to disturbance, predation, and harassment over a long time period (USDA USFS, 1995). Columnaris, a disease which afflicts salmonids in warm water, has also been known to cause mortality in adult spring Chinook and is more prevalent as the water temperatures increase (Bullock et al., 1986). Water temperatures in the South Fork Coquille River in the vicinity of Powers regularly exceed 70° F, which is near lethal limits for salmonids (USDI, 1996). During July of 1994, water temperatures in the South Fork Coquille River exceeded 80° F on seven consecutive days at the confluence of Woodward Creek (USDI, 1996). The South Fork Coquille River, from River Mile 18.1 to 61.9, is listed on the Oregon Department of Environmental Quality's 303(d) list as water quality limited for exceeding year round temperature criteria (DEQ, 2010). The South Fork Coquille River from river mile 42.1 to 61.9 is on the 303(d) list as water quality limited for exceeding summer temperature criteria (DEQ, 2010) (see Chapter 2 for more information on stream temperature).

Historically, spring Chinook were never as abundant on the South Fork Coquille River as their fall counterparts, numbering perhaps as high as 2,000 spawners at the turn of the 20th century (ODFW, 1993). Estimates based on pool surveys conducted in the mid-1950s showed less than 200 adults (Oregon Fish Commission, unpublished report, 1956). That number of adult returns remained relatively steady through the mid-1990s (ODFW, 1993) in part due to a broodstock program. Out of basin stock, from the Rogue River, were placed in the South Fork Coquille River for one year, with little success. A spring Chinook hatchery smolt program was instituted in 1984 and discontinued in 1993 (replaced by a hatchbox program). However, the 1994 return was too low to allow broodstock collection for this program. By the early 1990s, Coquille River spring Chinook were described as "depressed" (Nickelson et al., 1992) and classified as having a "high risk of extinction" (Nehlsen et al., 1991).

In 2005, ODFW reported on the status of Coastal spring Chinook Species Management Unit (SMU) as part of the Oregon Native Fish Status Report (ODFW, 2005). A SMU is a collection of populations from a common geographic region that share similar genetic and ecological characteristics. The Coastal spring Chinook SMU met only two of the six criteria so the near-term sustainability of the SMU is at risk (ODFW, 2005).The Coastal spring Chinook SMU includes nine populations located between Tillamook and the Coquille Subbasin. The Coquille population passed four of the six criteria used to evaluate the risk to the conservation of the population (ODFW, 2005). The Coquille population failed for abundance and productivity, but passed for existing, distribution, reproductive independence, and hybridization (ODFW, 2005).

The reduction in adult returns coincides with anthropogenic activities such as logging (especially riparian areas), splash dams, road building, mining and poaching. The splash dams and log drives which occurred in the South Fork Coquille River and Dement Creek from the late 1800s to the 1920s (Farnell, 1979) likely had an effect on habitat used by spring Chinook. Some of these potential effects would have been: elevated stream temperature; elevated sedimentation which interferes with feeding and clogs delicate gill filaments; reduced instream complexity (large wood, process-forming wood, complex pool habitat); channel incision resulting in active channel isolation from floodplain, which results in further channel incision; habitat fragmentation caused by road building; delayed movement of spawning substrate caused by road building/undersized culverts; prepping for splash dams meant removing instream wood/boulders which simplified habitat; and poaching removes adult fish in pools where they congregate and are vulnerable. In more recent times, summer low-flows exacerbated by irrigation withdrawals have rendered adult spring Chinook more vulnerable to poaching, human disturbance and water quality limitations.

Previous management documents have noted that spring Chinook Salmon in the South Fork Coquille River have been threatened by genetic impacts, due to hatchery manipulation of their very small population (USDI, 1996). Because the wild population is already small, its effective breeding population is small, and its genetic base is narrow. This puts survival potential for the population at an unusually high risk from the effects of normal environmental fluctuations in both freshwater and marine habitats. When even a small number of wild spawners are removed for a broodstock program, the wild population becomes smaller and its genetic base even more confined. Other potential problems occur when hatchery smolts produced a small sample of the breeding population contribute a high proportion of the genetic resources of natural spawning in a combination of wild and hatchery spawners. The net result is that genetic variability in the breeding population is further depressed (ODFW, 1992). An examination of hatchery programs and the natural spawning population on the South Fork Coquille River suggested that impacts such as those listed above are very likely occurring (ODFW, 1993).

Another factor that can negatively influence the spring Chinook population is interaction with the more numerous fall Chinook Salmon population. Examples include occupying the same spawning areas (redd superimposition), and competition in limited rearing areas (freshwater and estuarine). Lastly, recent increases in the introduced Smallmouth Bass population may negatively influence Chinook populations (both spring and fall) (ODFW, 2014).

From 1990–1999, pool counts conducted in prime holding pools revealed an average of 28 fish per year, with a peak count of 90 adults (ODFW, 2013). From 2000–2013, there were only four years where fish were observed, with a peak count of three adults (ODFW, 2013). Recent spring Chinook spawning surveys conducted by ODFW (2009–2012) failed to detect any adults in areas where they historically spawned (upstream of Powers) (ODFW, 2013). Anecdotal evidence suggests that a very limited number of spring Chinook are returning to the South Fork Coquille River. In the absence of genetic testing, it is difficult to say if the South Fork Coquille spring Chinook population is independent, or dependent upon straying from the closest possible populations (South Fork Umpqua or Rogue populations).

Fall Chinook

Fall Chinook enter the South Fork Coquille River during the first significant fall rains, usually between October and December, and initiate spawning shortly after their spring counterparts. Spawning has been observed from Broadbent upstream to Rock Creek, depending on water levels (USDI, 1996). Fry emerge from redds between February and May, depending on water temperature. The presmolts outmigrate toward the estuary through the summer months and into the fall (depending on water temperatures), and typically spend 3–5 years in the ocean before returning to spawn. Fall Chinook require deep holding pools to rest in during their upstream migration. Spawning does not occur to the upstream extent of tributaries as is common for Coho Salmon, steelhead and sea-run Cutthroat Trout (USDI, 1996). Fall Chinook do not usually encounter the high water temperatures endured by their spring counterparts, due to their relatively late spawning migration. However, water temperature is an important factor in juvenile Chinook rearing (USDI, 1996). As noted earlier, mainstem South Fork Coquille water temperatures are quite high during the summer rearing period, which forces most juvenile Chinook to move downstream to cooler tidewater.

Within the lower South Fork Coquille area, fall Chinook are known to spawn in Salmon Creek, Dement Creek, and the mainstem of the South Fork Coquille River (USDI, 1996). ODFW uses 0.8 miles of lower Salmon Creek and 1.0 mile (below the confluence of Rowland Creek) of the South Fork Coquille River as index reaches for monitoring fall Chinook spawning escapement. This data indicates that the spawning escapement of fall Chinook in the South Fork Coquille River has increased over the period of record (1959-2013, with occasional years missing). Spawning escapement of fall Chinook in Salmon Creek has also increased over the period of record (1952-2007, with several years missing especially in the early 1950s). Additionally, BLM monitored fall Chinook spawning in a 0.75-mile reach on Salmon Creek during the fall of 1994 (USDI BLM, 1995). This data indicates very high spawning density within the survey reach. However, it should be noted that since the 1960s, most fall Chinook spawning has occurred downstream of Powers, while spawners upstream of Powers declined (Hamilton and Remington, 1962; USDA USFS, 1995).

Hatchery releases of Coquille River and Coos River fall Chinook stocks occurred during the time that the hatchery on Lower Land Creek was in operation (during the early 1900s). The extent to which these releases affected the wild fall Chinook population in the South Fork Coquille is not known (USDI BLM, 1995).

The Coquille River population met all six criteria so the near-term sustainability of the population is not at risk (ODFW, 2005). Fall Chinook returns in the Coquille Subbasin have been relatively strong over the past several years. Escapement estimates from 1990 – 2012 averaged 9,062 adults, with a peak count of 32,318 in 2010 (ODFW, 2013). The South Fork Coquille River may account for as much as 60% of the entire Coquille Subbasin return. Geology and gravel recruitment, flow regime and stream gradient all combine to make the South Fork Coquille River some of the best spawning habitat for fall Chinook in the Coquille Subbasin (ODFW 2013). It is understood that high summer water temperatures and limited rearing habitat (particularly estuarine habitat) are the primary limiting factors to fall Chinook production. Future population impacts may result from competition and predation from introduced Smallmouth Bass.

Winter Steelhead (*Oncorhynchus mykiss*)

The Coquille steelhead population is within the Oregon Coast distinct population segments (DPS) and is not currently listed as an ESA population. Typically winter steelhead life histories include two to three years in fresh water and two to three years in salt water. Spawning occurs during winter from late December through June. Unlike most salmon, steelhead can be repeat spawners, with approximately 10% - 25% spawning a second time, 1% - 3% spawning a third time, and a rare few spawning a fourth time (CWA, 1997). The South Fork Coquille River is considered highly important for late fall and winter pre-smolt rearing of winter steelhead (Christopher Claire, ODFW, personal communication). Historical accounts suggest that steelhead were found in every accessible tributary. A hatchery program for steelhead utilizing native broodstock was initiated in 1990. Two acclimation sites for smolts are located within the action plan area: Woodward and Beaver Creek. All winter steelhead within the Oregon Coast DPS have experienced a decline in population size from historical levels, the significance of which has not been determined.

Pacific Lamprey (*Lampetra tridentata*)

The South Fork Coquille River provides critical habitat for Pacific Lamprey spawning and rearing life stages. Pacific Lamprey is an anadromous species that rear in freshwater streams, migrate out the ocean, and return to freshwater to spawn. Pacific Lamprey enter freshwater streams from March through July dependent on water temperatures. Spawning occurs in low gradient gravel and sandy streams. Male and female lamprey prepare redds for spawning by using their suction and tail to remove gravel. Adults will parish four days after spawning occurs. Eggs are deposited into redds and hatch within approximately 15 days. Another 15 days will be necessary before they emerge as eyeless larvae, known as ammocoetes. Ammocoetes burrow into depositional areas for a prolonged larval phase (4-10 years) where they feed primarily on detritus prior to metamorphosis into an eyed adult. The morphed adults migrate to the ocean during fall and spring where they exhibit parasitic characteristics feeding on marine fishes. They will remain in the ocean for approximately 18-40 months before returning to their natal streams as mature adults to spawn.

Lampreys are remnants of the world's oldest vertebrates and are both ecologically and culturally significant to the Coquille Subbasin. Pacific Lamprey is considered a "sensitive species" by Oregon Department of Fish and Wildlife, classified as "vulnerable". Species that are naturally-reproducing that face one or more threat to their population and/or habitat are considered "sensitive" (ODFW Sensitive Species List, 2008). Species that are not currently in danger of extinction but face one or more threats to their population and/or habitat and are expected to continue being threatened are considered "vulnerable". There are growing concerns about Pacific Lamprey population decline over the past few years. Due to their similarities in life cycle and habitat requirement to salmonids, the same limiting factors may result in population decline. Several years of data on lamprey presence in the upper South Fork Coquille beginning in the late 1990s was collected; this can be obtained by contacting the Powers Ranger District of the Rogue River – Siskiyou National Forest.

1.4 Land Management

The South Fork Coquille River is comprised of 48% private land and 52% federal land (managed by the USFS, BLM, and a small amount by BIA) (Figure 1-3). Private ownership is categorized as urban and rural residential and is comprised of a myriad of land activities (forest management, road construction, dairy farming, and agricultural land). Federal lands activities include forest management, road construction, and creating recreational opportunities.

1.4.a. Urban and Rural Residential

Within the South Fork Coquille Watershed there are four main populated areas: Powers, Myrtle Point, Gaylord, and Broadbent. Myrtle Point is located on Highway 42 and the others are located on the Powers Highway (Highway 242). The city of Powers is located 18 miles from Highway 42 on the Powers Highway (OR 542) (OR 542). It is situated along the South Fork Coquille River less than 150 feet above sea level. In the late 1850s to 1860s, pioneers began settling Powers, initially named Rural (USDA USFS, 1995). The town name was later changed to Powers after Albert H. Powers (USDA USFS, 1995). (see Section 2.1 for more information)

As of 2010, 689 people inhabited the city of Powers according to the U.S. Census Bureau (2010). Residents within this area are primarily employed in the service or natural resource industry (farming, fishing, timber, road construction, forest service employment).

The city of Myrtle Point is located along Highway 42. It is approximately 80 feet above sea level. Myrtle Point is located downstream from the confluence of the South and Middle Forks of the Coquille River and 1.2 river miles upstream from the confluence of the North and South Forks of the Coquille River (where the Coquille River begins). As of 2010, 2,514 people inhabit the city of Myrtle Point (U.S. Census Bureau, 2010). Residents within this area are primarily employed in private business, service, construction, production or natural resource industry (farming, fishing, timber, road construction).

Gaylord and Broadbent are unincorporated communities within the South Fork Coquille River north of Powers. These areas are within the broad valley of the South Fork Coquille River and contain rich agricultural soils. Early settlers realized the value of the rich soils and cleared the valley for pasture and crop land.

1.4.b. Agricultural

Agriculture has been a part of the Coquille Subbasin and the South Fork Coquille Watershed for over a century due to deep floodplains and valleys with fertile soil. In the late 1800s extensive marshes and wetlands throughout the Coquille valley were diked, drained, and converted to highly productive agricultural lands. Currently, there is a wide variety of livestock grazing in the South Fork Coquille Watershed including horses, sheep, cattle, and goats. In the lower portion of the South Fork Coquille River pasture and hay fields remain the predominant land use.

1.4.c. Forestry

The watershed landscape is dominated by conifer forests containing a patchwork of age classes and species ranging from oak savannahs to conifer forests dominated by Douglas fir or pines. The USFS manages the upper portion of the watershed and the BLM manages the headwaters of Rowland, Baker, and Salmon Creek within the lower portion of the watershed. Private and tribal forests are scattered throughout the watershed. (More information on Management private and federal forest land can be found in Section 2.3.b.)

1.4.d. Recreation

The South Fork Coquille River is a popular waterway and heavily used at certain times of the year. Fishing, swimming, boating, rafting, camping, and gold panning are some of the most popular activities. The remote location of the South Fork Coquille Watershed helps to keep large crowds in check, though the river is still close enough to Roseburg, Eugene and Medford to attract visitors from those areas. Some of the main recreational activities are: fishing, swimming, rafting, camping, and gold panning.

Fishing

Anglers pursue several species of fish in the South Fork Coquille River. Winter steelhead, fall Chinook, Cutthroat Trout, and, more recently, illegally introduced Smallmouth Bass, are all caught in good numbers. Bank access is limited; however, Highway 242 (the Powers Highway) parallels the river for several miles allowing some access. Most anglers take advantage of unimproved boat launches between Myrtle Point and Powers. The South Fork Coquille River carries a lot of fine sediment, and the river is not quick to clear after a rain storm. The river is closed to all fishing from milepost 4 on the Powers-Agness Road (above Powers) to Coquille River Falls (approx. 12 miles above Powers), including all tributaries.

Winter Steelhead

The most popular fishery on the South Fork Coquille River is for winter steelhead. Fishing takes place from December to April, with best results in January. Most fishing takes place below Powers near ODFW steelhead acclimation sites at Woodward and Beaver Creeks. Anglers use gear, bait and fly fish all with good success. Generally, anglers fish lower in the system during low water, and higher in the system after a freshet.

Fall Chinook Salmon

Most angling for fall Chinook on the South Fork Coquille River takes place near the town of Myrtle Point. Fish are present in this reach September – October after water conditions allow fish movement from lower in the system. Fall Chinook congregate in several deep, slow moving holes from Arago to the confluence of the Middle Fork Coquille waiting for higher flows. Most anglers who fish for fall Chinook use bait and access stream reaches from the bank. The South Fork Coquille River is closed to all salmon angling above the Middle Fork Coquille. These regulations are subject to change according to the current ODFW fishing regulations. As of 2014, Chinook fishing does not open above the confluence with the North Fork Coquille until October 1.

Cutthroat Trout

The best Cutthroat Trout fishing takes place shortly after the season opens (late May) until water temperatures become too warm; and again in the fall after the water cools. Anglers use bait, gear, and fly fish for trout throughout the system. A unique and uncrowded fishery can be found above Coquille River Falls. Anglers may even be able to catch native Rainbow Trout. Coquille River Falls is a barrier to all upstream movement by salmon and steelhead.

Smallmouth Bass

Fishing for illegally introduced Smallmouth Bass is becoming increasingly popular. Most angling effort takes place May – September. Smallmouth Bass are growing in number and available downstream of Powers. Recent snorkel surveys conducted by ODFW showed several specimens in the 14-inch range, and large numbers of 0+ age fish (ODFW, 2014). It is highly likely that Smallmouth Bass numbers will continue to increase, impacting native fish species through competition for food and cover, and predation. Fish species most vulnerable to Smallmouth Bass impacts include Pacific Lamprey because of an extended freshwater rearing time (up to 7 years) for the Pacific Lamprey and fall Chinook because of their small size at outmigration. ODFW has removed all daily limits on Smallmouth Bass hoping to draw angler interest. While it may not be possible to remove Smallmouth Bass from the South Fork Coquille, it may be possible to reduce the number of large fish through angling.

Swimming

Several popular swimming areas are easily accessible along Highway 242 and the Powers-Agness Highway. Most picnicking and day use activities occur July – September.

Boating Including Rafting and Kayaking

Much of the boating in the South Fork Coquille River is done by fisherman or other recreationalists. There is often some rafting and whitewater kayaking, but it typically takes place below the USFS boundary. Rafting in the middle and upper portions of the South Fork Coquille River requires a high level of experience. The South Fork Coquille above Powers flows through a rugged canyon, making boating and rescue extremely difficult.

Camping

Most camping occurs on the Rogue-Siskiyou National Forest above Powers from June–September. There are a number of improved campgrounds as well as unimproved sites along the river. The Powers-Agness Highway is a backcountry route connecting Powers with the Lower Rogue River.

Recreational Mining

Recreational gold panning occurs in the South Fork Coquille River and is concentrated in the China Flat area. Recreational, small-scale suction dredging occurs along the South Fork Coquille River as well (Jones et al., 2012).

1.4.e. Stream Channel Activities

The mainstem and tributary stream channels in the South Fork Coquille Watershed have been impacted by many factors. These include stream cleaning and splash damming which removed large wood from channels and affected bed and bank conditions, gravel mining, mineral mining, dredging, and irrigation. All of these will be discussed in depth in Chapter 2.

1.5 Limiting Factors – A Brief Overview

The current landscape has vastly changed since early settlement of the South Fork Coquille River. The main forks of the Coquille River were once lined with dense riparian vegetation consisting of willow, cottonwood, myrtle, alder, and other hardwoods. It was reported that the channel of the mainstem Coquille River was likened to traveling through a tunnel in some reaches due to the height and overhang of the vegetation (Benner, 1991). Settlement required removal of this dense vegetation for urbanization, agricultural and timber resources. The removal of stream bank vegetation, instream boulders and downed wood resulted in the loss of significant aquatic habitat.

The loss of habitat and water quality contributes towards the decline of salmonid populations on the Oregon Coast. These attributes will be considered limiting factors – physical, biological, or chemical features experienced by fish at the population, intermediate (e.g. stratum or major population grouping), or ESU levels that result in reduction in salmonid population at any life stage (Coquille Indian Tribe, 2007). Primary limiting factors within the South Fork Coquille River are excessive stream temperature, periodic low flows, sedimentation, and habitat complexity. A further discussion of limiting factors and contributors will be presented in Chapter 2.

1.6 Inter-Fluve, Inc. Report

As part of this project, the Coquille Watershed Association contracted with Inter-Fluve, Inc. to do an analysis of the project area (Inter-Fluve, Inc. 2013). The results of this work are described throughout the action plan. Inter-Fluve, Inc. (2013) breaks down the mainstem South Fork Coquille River into stream reaches (see Figure 1-10 and Table 1-3). There have been other studies on the South Fork Coquille River which broke down the river by reaches. A cross walk of these compared to Inter-Fluve, Inc. (2013) is shown in Table 1-3. In this report, all references to stream reaches, unless stated below, will be referring to the Inter-Fluve, Inc. (2013) reach numbers.

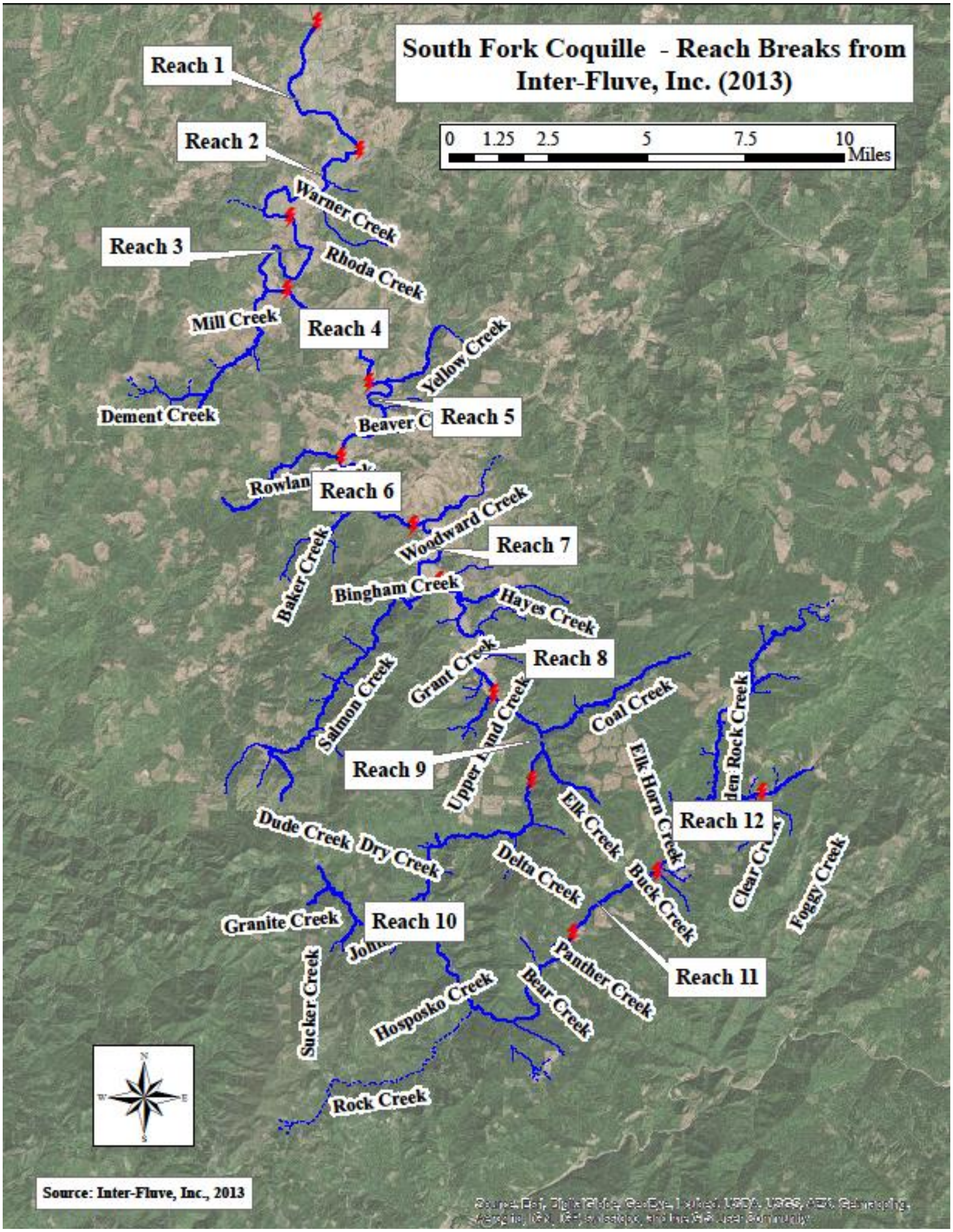


Figure 1- 10. Reaches of the South Fork Coquille River according to Inter-Fluve, Inc., (2013).

Table 1- 3. South Fork Coquille River reach name crosswalk by reference.

River Mile	Site Description	Inter-Fluve, Inc. (2013)	Clearwater BioStudies (2003)	USGS Study (Jones et al. 2012)
0-4.8	Between confluence of North and Middle Forks. Myrtle Point is in this reach.	1	SFC-1	Myrtle Point Reach
4.8-10.2	From upstream of Middle Fork to the West Side Road bridge in Broadbent.	2	SFC-2	Broadbent Reach (in part)
10.2-15.3	From the West Side Road Bridge to just upstream of Dement Creek.	3	SFC-3	Broadbent Reach (in part)
15.3-19.6	Just upstream of Dement Creek to just upstream of the Gaylord Bridge.	4	SFC-4 (plus 0.4 miles of SFC-5)	Broadbent Reach (in part)
19.6-23.5	Just upstream of the Gaylord Bridge to near the confluence of Rowland Creek.	5	SFC-5	Broadbent Reach (furthest upstream portion)
23.5-27.6	From the confluence of Rowland Creek to the bridge crossing just downstream of Powers.	6	SFC-6 (approx-imately)	Powers Reach (in part)
27.6-30.6	From the bridge crossing just downstream of Powers and the confluence of Woodward Creek to just downstream of the confluence of Mill Creek.	7	SFC-7 (approx-imately)	Powers Reach (in part)
30.6-35.1	From just downstream of the confluence of Mill Creek to the confluence of Upper Land Creek (near the boundary of the Rogue River-Siskiyou National Forest).	8	SFC-8 (approx-imately)	Powers Reach (in part)
35.1-38.2	From the confluence of Upper Land Creek (near boundary of the Rogue River-Siskiyou National Forest) to the confluence of Sand Rock Creek where slope increases abruptly.	9	N/A	N/A
38.2-52.6	From the confluence of Sand Rock Creek to the confluence of Panther Creek.	10	N/A	N/A
52.6-55.3	From the confluence of Panther Creek to the confluence of Buck Creek.	11	N/A	N/A
55.3-60.4	From the confluence of Buck Creek to just upstream of Foggy Creek and the headwaters of the SF Coquille River.	12	N/A	N/A

*Note: Reach numbers in this Action Plan correspond with reach numbers in Inter-Fluve, Inc. (2013)

Chapter 2: Aquatic Habitat Limiting Factors – Establishing Current Concerns with Historical Context

2.1 Habitat Limitations with Historical Context

2.1.a. History of the South Fork Coquille Watershed

Historical accounts and observations are significant reference points for comparing channel conditions. The historical content presented in this document is not the complete history of the area, but provides reference information for evaluating the South Fork Coquille River condition.

The Coquille system first appeared on maps around 1850. The oldest written account about the Coquille River system and its inhabitants is Alexander McLeod's 1826 accounts of his trading and trapping exploration for the Hudson's Bay Company. McLeod's assignment was to locate and investigate a "great river" with beaver-rich streams south of the Umpqua River. His journey took him to the Coquille system where he worked with local natives traveling southward searching for beaver-rich streams. (Hall, 1995)

An early account from of the Coquille River explained, "… when white man arrived on the scene [lower Coquille River], in places their tops met and interlaced above the streams. Travel upon the Coquille is through scenes of enchantment, and the sluggish river seems like dim aisles in ancient cathedrals." (Dodge, 1898)

McLeod's search for a route to the Umpqua Valley led him upstream into the South Fork Coquille River through a trail that lay on the west bank of the South Fork past Whobrey Mountain up to Rock Creek then climbed to the divide at Agness Pass (through what is now the Rogue River - Siskiyou National Forest) and encountered a number of Indian villages likely inhabited by the Upper Coquille band of the Athabascan Indians (Hall, 1995). (They are also referred to as Athapaskan by authors (Tveskov, 2004). The Cow Creek band of the Umpqua Tribe and several bands of Rogue River Indians may have used the headwater valley known as "Eden Valley" (USDA USFS, 1995).

According to Tsekov (2004), the physical location of Upper South Fork Coquille River, including what is now the town of Powers, played a large role in the political, cultural, and economic status of the Native Americans living there prior to European settlement. That being that the area is relatively isolated and difficult to access. The villages of the area were well-populated and other villages referred to those in the Upper South Fork of the Coquille in reverence to their power and wealth (Tsekov, 2004).

After McLeod's expeditions, there were more fur trappers and traders in the South Fork Coquille Watershed during the 1820s (USDA USFS, 1995). There was one main travel route that followed the South Fork Coquille River up to Rock Creek then climbed to the divide at Agness Pass (through what is today's Siskiyou National Forest) and to Illahe and Agness on the Rogue River (USDA USFS, 1995). After 1868, pelters, or hide hunters, established camps throughout the Coquille area (USDA USFS, 1995).

In the early 1850s, both miners and settlers started moving into the area (USDA USFS, 1995). A few pioneers in the late 1850s to 1860s settled in Powers, initially named Rural (USDA USFS, 1995). The name of the Rural settlement was changed to Powers after Albert H. Powers (USDA USFS, 1995). Albert Powers was one of the co-founders of the Smith-Powers Logging Company which was formed in the early 1900s (Ward, 1973). In 1915, to facilitate the logging industry, the railroad began operating between Powers and Myrtle Point, with six covered bridges and one tunnel in that stretch (Ward, 1973). The biggest changes to the watershed began with the appearance of the railroad and the establishment of the Smith and Powers Logging Company (USDA USFS, 1995). Early logging occurred in the Salmon and Land Creek drainages, later extending east of Powers to Eden Ridge (USDA USFS, 1995). Settlement continued throughout the entire watershed during this time. At its height the upper Eden Valley area contained 7-10 families in the natural meadows, with a post office, school, two sawmills, and an emergency airplane landing field existed (USDA USFS, 1995). It was during this era that the watershed also began to be roaded. Major connections were completed including the road along the South Fork Coquille River, the road from Glendale to the Eden Valley Ranger Station, and the road connecting Powers with Agness, which is along to the Rogue River. (USDA USFS, 1995)

Subsistence farming and ranching was prevalent in areas such as Eden Valley up until the mid-1900s. The meadows and pastures used during this time are still evident and include Ash Swamp, Foggy Creek, and Eden Valley meadows. The combination of relatively open topography and historic land usage in the Eden Valley area may have had an impact on riparian and upslope vegetation continuing into modern times. For instance, the upper Eden Valley area is known for its frost pocket conditions that have forced landowners to alter their seedling planting mixes (Steve Wickham, personal communication). Beaver are also common on some tributaries in the upper valley. Large beaver dam complexes have resulted in a number of wide, exposed reaches with little adjacent shade in the upper South Fork, Foggy Creek, and Clear Creek tributaries. Foggy Creek has extensive beaver dam complexes (Steve Wickham, personal communication).

Extensive logging and road building in the headwaters of the South Fork Coquille began in the 1950s (USDS USFS, 2012). The logging techniques of that era resulted in large areas with a lack of trees across large landscapes which results in a decrease in evapotranspiration and tree interception resulting in an increase in peak flows (Rothacher, 1973). Increases in peak or storm flows in winter and spring can alter channel morphology by flushing smaller substrate, causing the channel to downcut, and increase stream bank failures. Studies on increased peak flows are varied in their findings on how much increase in flow would result from a given amount of timber harvest. Most peak flow studies agree that the effects of harvest treatment decreases as the flow event size increases (Rothacher, 1971; Rothacher 1973; and Wright et al., 1990) and is not detectable for flows with a two year return interval or greater (Harr, et al., 1975; Ziemer, 1981; Thomas and Megahan, 1998; and Thomas and Megahan, 2001). Large amounts of roads in an area modify storm flow peaks by reducing infiltration on compacted surfaces, allowing rapid surface runoff, or by intercepting subsurface flow and surface runoff, and channeling it more directly into streams (Ziemer, 1981).

The Southern Pacific made its last run up to Powers in 1971 when the last lumber mill in the area closed (Ward, 1973). Hopes for a lasting railroad in the area were squelched when new laws prohibited the use of oversized log trucks on public roads, denying the trucks serving the railroad access to the railway (Ward, 1973).

2.1.b. Historic Channel Condition

The condition of the South Fork Coquille River channel and that of its associated riparian vegetation are closely inter-related. An understanding of pre-settlement conditions of the South Fork Coquille River riparian zone may be useful in estimating the river banks' ability to support woody riparian vegetation as the modern channel adjusts to both natural disturbances (erosion due to non-cohesive soils, geologic uplift, floods, natural landslides, and the general dynamic interaction of natural forces) and to the significant anthropogenic impacts (vegetation removal, instream wood removal and dredging, headwaters and upland logging, roads, splash damming, and livestock pressure) of the past two centuries.

Though little information in the form of channel topography is available to describe historical channel conditions, a recreation of the planform of the 1870 channel for a short stretch of the South Fork Coquille upstream of its confluence with the Middle Coquille suggests significant changes in the channel's meander pattern (Figure 2-1) (Florsheim and Williams, 1995 and Clearwater BioStudies, Inc., 2003). The reconstruction, based on General Land Office (GLO) surveys around 1870, suggests that the channel was in a very similar position to the current channel, but with increased sinuosity and meanders with higher amplitudes and shorter wavelengths. This tighter meander pattern was likely supported by a more robust riparian corridor that provided bank stability and hydraulic roughness, regulating shear stress during flood flows. Also, the changes in sediment inputs following land clearing and logging and channel modifications such as snagging (snagging is the act of mechanically removing large wood from the channel) and dredging that eventually degraded the channel had not disturbed the system at that time (Inter-Fluve, Inc., 2013).

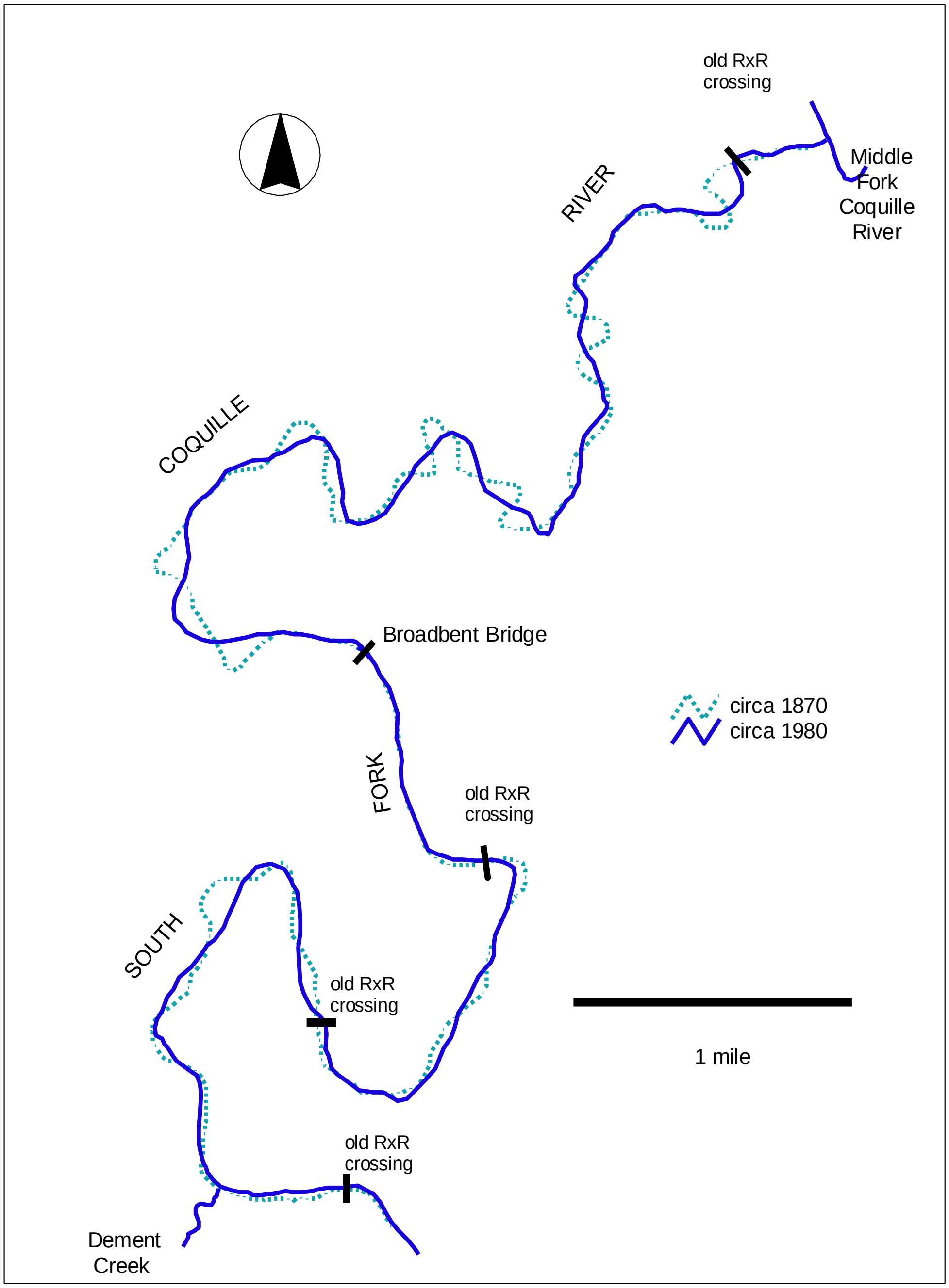


Figure 8. Changes in the alignment of the South Fork Coquille River between the Middle Fork and Dement (study reaches SFC-2 and SFC-3), 1870-1980. River positions given represent channel mid-lines.

Figure 2- 1. 1870 and 1980 South Fork Coquille River location. 1870 data from General Land Office (GLO) and 1980 data from USGS (Figure 8 in Clearwater BioStudies, Inc., 2003).

Benner's (1991) reconstruction of bottomland vegetation includes the lower 10 miles of the South Fork Coquille. Within this area, the majority of the bottomlands were forested floodplain with 3,217 acres out of 3,292 total bottomland acres considered forested. The bottomland area also included 75 marshy acres. The tree species described in these areas were dominantly small diameter, moisture tolerant species such as maple, alder, and ash with a brushy understory. By some accounts the canopy of the riparian forest stretched across the river and formed a tunnel over the stream channel. Most early surveyors noted extensive and prolonged annual flooding of the river bottomlands (Benner, 1991). The extent of this annual flooding suggests a well-connected channel and floodplain system in the historic South Fork Coquille that would have provided large off-channel habitat areas for juvenile salmonid rearing. This is a distinct difference from the incised and disconnected channel of today, with floodplains predominantly in agricultural production and only periodically inundated by large floods (Inter-Fluve, Inc., 2013).

The uplands of the South Fork Coquille Watershed were heavily forested providing a source of large wood to the tributaries and river system. In the river, they formed log jams throughout the river (Benner, 1991). Other accounts, such as those by the Corps of Engineers (1891) described in Jones et al. (2012), also discuss wood transport in the Coquille River system: "The various forks of the Coquille drain densely timbered territory, and at every freshet many trees, stumps, etc., are brought down. Some of these lodge at different points, forming isolated snags, or are grouped together into jams. These snags and jams, in turn, induce the formation of shoals of sand and gravel." Shoals are bars that are typically linear and often extend completely across a body of water.

2.1.c. Dredging

The Coquille and South Fork Coquille Rivers were used for commodity transport up to the area around Myrtle Point in the late 1800s and early 1900s (Dodge, 1898). Head of tide was 41 river miles from the ocean, at the confluence of the Middle and South Forks of the Coquille River, whereas in 1991, it was at 37 river miles (Benner, 1991). Navigability was also noted to the confluence of the South and Middle Forks, and the channel was noted as navigable at all flows and all seasons by several early surveyors (Inter-Fluve, Inc., 2013). Dredging was eventually required to maintain boat access as the channel aggraded from increased sediment inputs caused by early land-use development (Inter-Fluve, Inc., 2013). Between 1881 and 1902, the U.S. Army Corps of Engineers (ACOE) conducted dredging operations to improve navigability of the Coquille River above the city of Coquille (Coquille Indian Tribe, 2007).

Accounts of the river condition and dredging history provide insight into the river condition at that time. In 1886, it was noted that there was difficulty during summer low flows traveling upriver above the North Fork confluence to Myrtle Point (Benner, 1991). In 1891, six shoals had formed on the last 4.5 miles of river between Arago and Myrtle Point, probably as a result of sediment from a landslide above Myrtle Point after the 1890 flood (see Historical Flooding section below) (Benner, 1991). These shoals filled up with alluvial deposits and by 1903, the depth between Roberts landing and Myrtle Point was 1-3 feet (Benner, 1991). In 1894, the U. S. ACOE sluiced the shoals but by 1897 the six shoals plus one more had returned. In 1898 the North Fork to Myrtle Point channel is described as 0.5-1 foot in depth and in 1900 the river was dredged again from Arago to Rackleff's Landing, but that filled up again by 1901 (Benner, 1991). Because the results of dredging were only temporary, pile-dike construction and dredging attempts in the 1890s failed to restore a navigable channel (CWA, 1997). There were also significant amounts of large woody material in the channel, enough to necessitate "snagging" the channel to remove wood to maintain boat traffic (Inter-Fluve, 2013). By several accounts, large floods would also create log jams that choked the entire river channel and would take days to break apart (Inter-Fluve, 2013). In 1902, the U.S. ACOE ceased dredging operations to maintain navigability above Coquille, with the exception of occasional snagging work (Benner, 1991).

The Port of Coquille Commission was created in 1911, about the time that the first splash dams were being built (CWA, 1997). One of the main purposes of the Port of Coquille included maintaining navigability of the South Fork Coquille below Myrtle Point (Benner, 1991). Upriver, the Commission's responsibilities included the improvement and maintenance of channels for navigational purposes, as well as log transportation (CWA, 1997). From 1915-1923, the Port of Coquille Commission repeatedly dredged and snagged the river up to Myrtle Point to a four foot depth channel.

The commercial necessity of maintaining channel navigability was a source for channel disturbance from 1878 into the 1920s (Inter-Fluve, Inc., 2013). Sediment eroded from headcutting in the South Fork Coquille River and tributaries would have been deposited in the lower gradient newly dredged reach downstream adding to the ongoing maintenance requirements (Florsheim and Williams, 1995). During that time when the channel was actively dredged and snagged, both the source for in-channel wood (riparian forests) and existing in-channel wood itself was being actively removed from the system (Inter-Fluve, Inc., 2013). The removal of the wood can destabilize the bed and banks, and removes a mechanism for trapping, storing, and hydraulically sorting sediment (Inter-Fluve, Inc., 2013).

2.1.d. Stream Cleaning, Splash Damming, and Log Drives

Prior to the construction of forest roads, the South Fork Coquille River and its tributaries were the only economic option for logging companies to transport logs downriver to the mills (Benner, 1991 and Miller, 2010), until the Smith and Powers Logging company brought in the railroad to the watershed in 1915 (Ward, 1973).

According to Farnell (1979), logs were being driven down to Myrtle Point as early as 1891. Log drives continued to be located further and further up the South Fork Coquille River and to Rural (later named Powers) by 1912 (Figure 2-2). The U.S. Army Corps of Engineers reported that in 1914 logging was occurring up to River Mile 27 (Reach 7). (Farnell, 1979)

The transport of logs down the tributaries could only occur during the rainy winter season during high flow events, when instream logs were naturally transported downstream as well, which was one limitation of log drives (Benner, 1991). Around 1911, the use of splash dams to store water that would be released when needed to float logs downstream, began in the watershed (Benner, 1991), specifically in Dement Creek (Florsheim and Williams, 1995 and Figure 2-2). Therefore, the stream and river from the splash dam on Dement Creek downstream to the confluence of South Fork Coquille River and the river below that (Reaches 1-3) were impacted by the splash dam. In addition, the Middle Fork Coquille River had 12 splash dams, which affected Reach 1 which is downstream from the confluence of the Middle Fork (Inter-Fluve, Inc., 2013). In conjunction with the splash dams, the Port of Coquille Commission and others cleared riparian vegetation and removed large wood and boulders downstream of splash dams to maximize the efficiency of log transport and improve navigability (Benner, 1991).

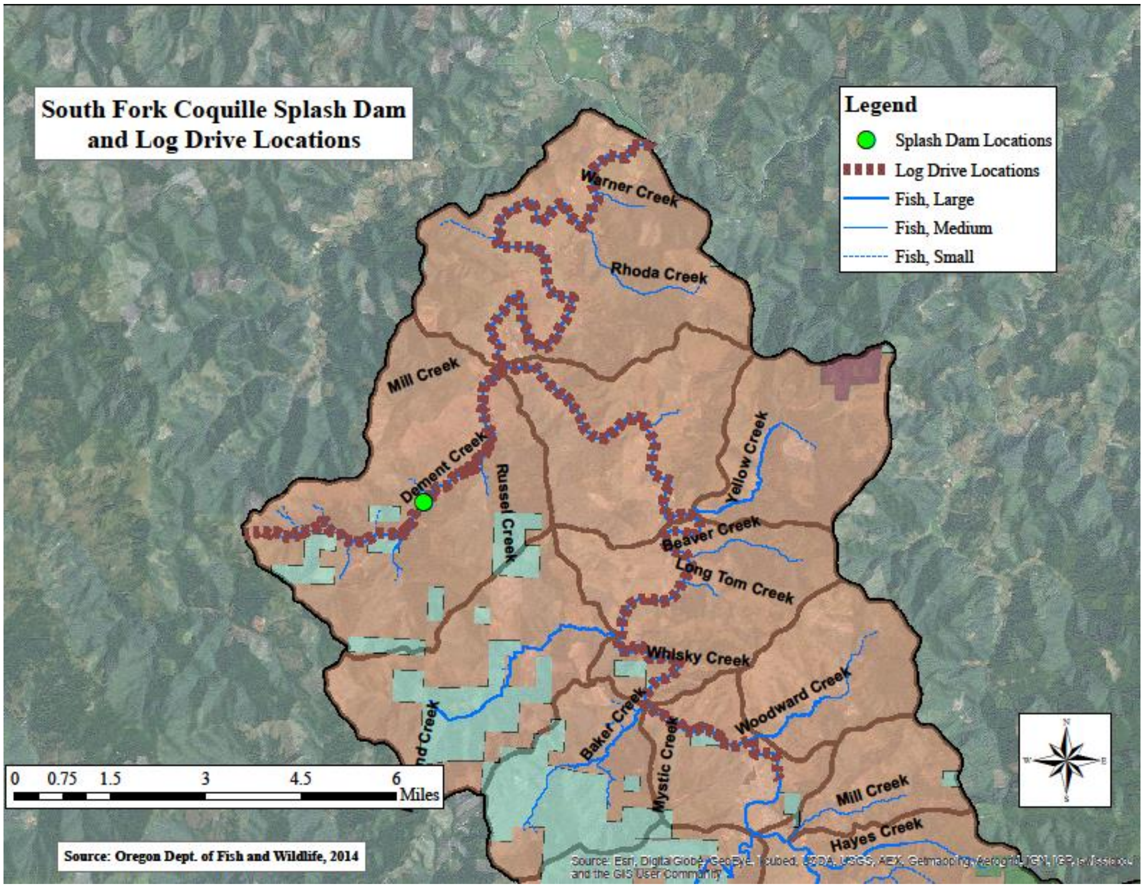


Figure 2- 2. Map of locations of splash dams and log drive channels within the South Fork Coquille River (Miller, 2010). Stream sizes are according to Oregon Administrative Rules.

The effects of splash damming are extensive in the affected stream. Severe scouring from splash damming causes a widespread affect downstream (Miller, 2010). Furthermore, the loss of vegetation results in increased erosion and therefore loss of habitat and increased stream power. The South Fork Coquille River was used for these log drives until 1914, but decreased significantly with the advent of the railroad during that time; however, the Coquille Lumber Company floated logs from River Miles 16-17 in 1921 (Farnell, 1979). By 1915, the Port of Coquille Commission recognized some of the negative effects of splash dams and recommended not removing vegetation on the outside bends or in the area where banks were eroding if navigation was not being impacted (Florsheim and Williams, 1995).

2.1.e. Historic Mineral Mining

In the 1850s mining began in the South Fork Coquille Watershed (Jones et al., 2012). There were placer mines in the South Fork Coquille and tributaries, with Johnson and Rock Creek actively mined with most mines being gold and some nickel (USDA USFS, 1995). Miners also found gold in Salmon Creek (Dodge, 1898). During the late 1800s a Chinese settlement, with a population of approximately 1000, on China Flat worked Johnson Creek until the homesteaders of the Powers area (the North Carolina Settlement) ran them off in the 1890s and in 1891, two large slides on Johnson Creek buried most of the miners' digs (USDA USFS, 1995). The placer deposits along the South Fork Coquille River and its tributaries were likely hydraulically mined which removes large volumes of sediment from streamside terraces (Jones et al., 2012). Mining, especially hydraulic mining, has the potential to significantly alter the stream since the bed and banks are overturned while looking for precious metals.

2.1.f. Historic Flooding and Fires

Historical 19th century large floods within the Coquille River Subbbasin occurred in 1861, 1881, and 1890 (Benner, 1991). The 1861 flood shifted the location of the Coquille River mouth, and the 1890 flood triggered a large landslide on Salmon Creek, a tributary joining the South Fork Coquille River within Reach 7. The 1890 flood event was significant because the landslide in Salmon Creek caused a dam break flood that instantly raised the river level some 10 to 25 feet and swept down the South Fork Coquille River all the way to Coquille City, leaving a massive pile of timber in the channel (Dodge, 1898). In 1889, a fire burned the Salmon Creek drainage, which preceded the 1890 flood that triggered the large slide and debris flow (Dodge, 1898). Twentieth century floods include major floods in 1955, 1964 (a 100 year recurrence interval flood), and 1996 (a short-duration high-intensity 50 year recurrence interval flood). Since European settlement in the area, the Coquille Subbasin has experienced fewer widespread forest fires than neighboring Rogue Subbasins and Coos River Subbasin (Jones et al., 2012).

2.2 Water Quality Limitations, Contributing Factors, and Effects on Aquatic Organisms

2.2.a. Beneficial Uses

Oregon's numeric and narrative water quality standards have been established to protect designated beneficial uses (Table 2-1). In practice, water quality standards have been set at a level to protect the most sensitive beneficial uses and seasonal standards may be applied for uses that do not occur year-round. Cold-water aquatic organisms, such as salmon and trout, also known as salmonids, are the most sensitive beneficial uses occurring in the watershed (DEQ, 1995a).

Table 2- 1. Beneficial uses in the South Coast Basin – OAR 340-041-300, Table 300A (DEQ, 2003b).

Public Domestic Water Supply[1]	Aesthetic Quality
Private Domestic Water Supply[1]	Fish and Aquatic Life[2]
Industrial Water Supply	Wildlife and Hunting
Irrigation	Fishing
Livestock Watering	Water Contact Recreation
Boating	Hydro Power
[1]With adequate pre-treatment (filtration and disinfection) and natural quality to meet drinking water standards.	
[2]See figures 300A and 300B in OAR 340-41 for fish use designations for this watershed (Figures 1-5 and 1-6 from DEQ, 2003a and DEQ, 2005a).	

<u>2.2.b. Long-term Water Quality Trends</u>

DEQ operates a statewide ambient water quality monitoring network which includes a site located on the South Fork Coquille River at Broadbent. DEQ began routine monitoring at this site in 1982 and currently conducts water quality monitoring at this location on average six times annually. Parameters include conventional water quality pollutants including: water temperature, dissolved oxygen, pH, conductivity, turbidity, alkalinity, bacteria, total organic carbon, and nutrients including: total phosphorus, dissolved orthophosphate, nitrate/nitrite, and ammonia. Information collected at this site is used to assess general water quality conditions and trends.

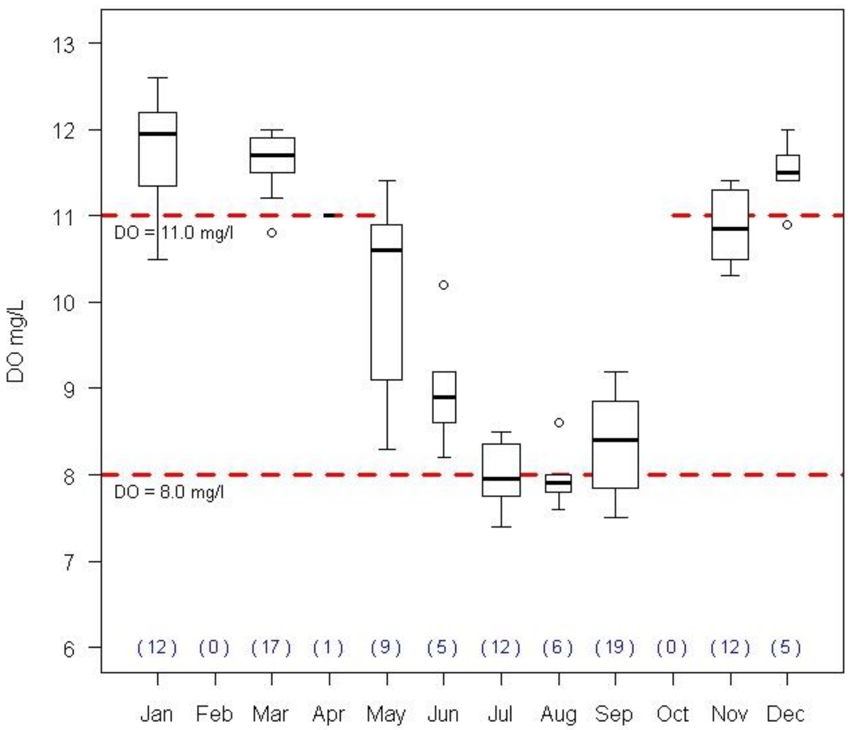
DEQ's Oregon Water Quality Index (OWQI) provides a general assessment of water quality at a site by combining information from eight different sub-indices: temperature (T), dissolved oxygen (DO), pH, biochemical oxygen demand (BOD), total solids (TS), nutrients (nitrogen (N) and phosphorus (P)) and bacteria (BACT). Low flow summer months (June - September) and higher flow fall, winter, and spring (FWS, October - May) average values were calculated and compared. Overall the water quality at the South Fork Coquille River at Broadbent monitoring site is ranked as fair with no significant overall trend toward improvement or declining water quality. Sub index scores for dissolved oxygen show improvement but phosphorus loads appear to be increasing. Sub index scores for the parameters temperature and total solids are ranked as poor. (DEQ, 2012a)

DEQ also used monthly box and whisker plots to assess the monthly distribution of the water quality data for the period 1990 – 2011. Plots were developed for the parameters temperature, dissolved oxygen, bacteria, and pH.

Box and whisker plot summaries in the table below (Table 2-2) show the months when water quality criteria or standards are not being met and statistically significant trends for the parameters: dissolved oxygen (Figure 2-3), pH (Figure 2-4), temperature (Figure 2-5), and bacteria (Figure 2-6) (DEQ, 2014). Please see sections 2.2.d-2.2.i for further discussion of the biological impacts of these parameters.

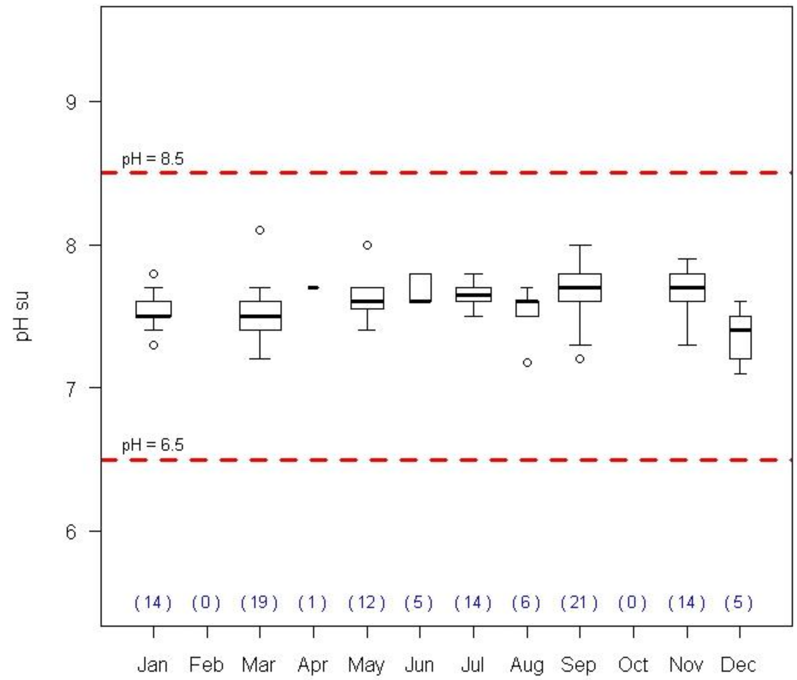
Table 2- 2. South Fork Coquille River at Broadbent RM 10. 1990-2011 box and whisker plots summarized (DEQ, 2014).

Parameter	Criteria	Period of Criteria/Standard Nonattainment
Bacteria	Recreational Contact	February
Temperature	Fish Rearing	June, July, August, September
Temperature	Fish Spawning	May, October
Dissolved Oxygen	Fish Rearing	July, August, September
Dissolved Oxygen	Fish Spawning	November
pH	Year around	Attains



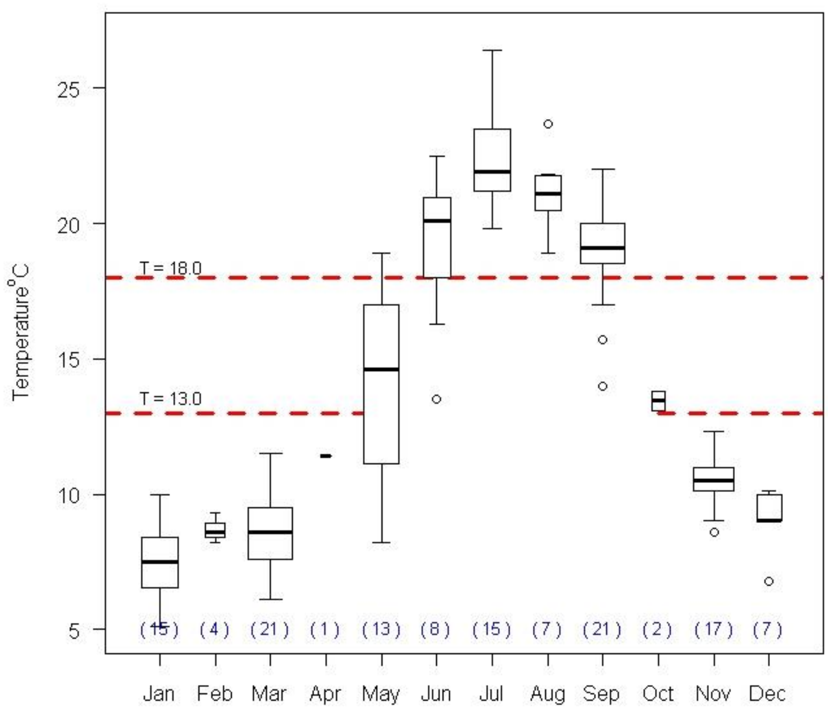
Month (number of samples)
Red lines show water quality standards (spawning and rearing)

Figure 2- 3. South Fork Coquille River at Broadbent – dissolved oxygen (1990-2011) (DEQ, 2014).



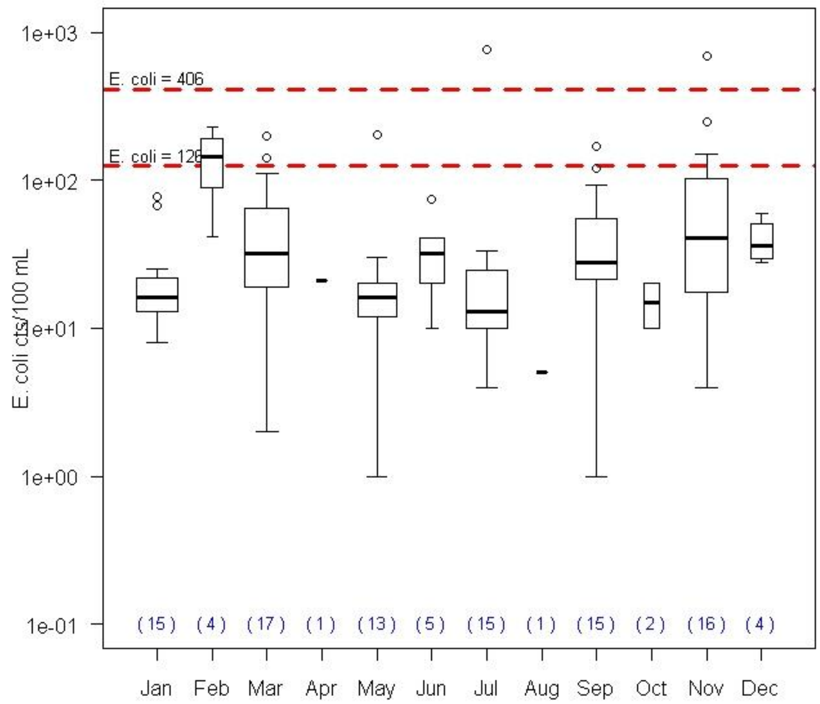
Month (number of samples)
Red lines show water quality standards (upper and lower limits of allowed range)

Figure 2- 4. South Fork Coquille River at Broadbent – pH (1990-2011) (DEQ, 2014).



Month (number of samples)
*18.0° C = 64.4° F / 13.0° C = 55.4° F
Red lines show water quality biologically based numeric criteria (spawning and rearing)

Figure 2- 5. South Fork Coquille River at Broadbent – temperature (1990-2011) (DEQ, 2014).



Month (number of samples)
Red lines show water quality numeric criteria (single sample maximum and log mean)

Figure 2- 6. South Fork Coquille River at Broadbent – bacteria (1990-2011) (DEQ, 2014).

Trend analysis was also conducted to determine the overall pattern of change in a given water quality parameter over time. A trend line is a straight line that connects two or more points. A positive sloping line is defined as an uptrend. A negative sloping line is defined as a downtrend. The linear trend in a dataset is considered to be statistically significant if the p-value is less than the customary cutoff of 0.05 (DEQ, 2014).

Statistically significant trends for the parameters of temperature, dissolved oxygen, bacteria, and pH are summarized in Table 2-3. Trend plots for each parameter are provided in Figures 2-7 through 2-10.

Table 2- 3. South Fork Coquille River at Broadbent 1990-2011, parameter trends summarized (DEQ, 2014).

Parameter	Significant Trend
Bacteria	None
Temperature	Cooling
Dissolved Oxygen	None
pH	None

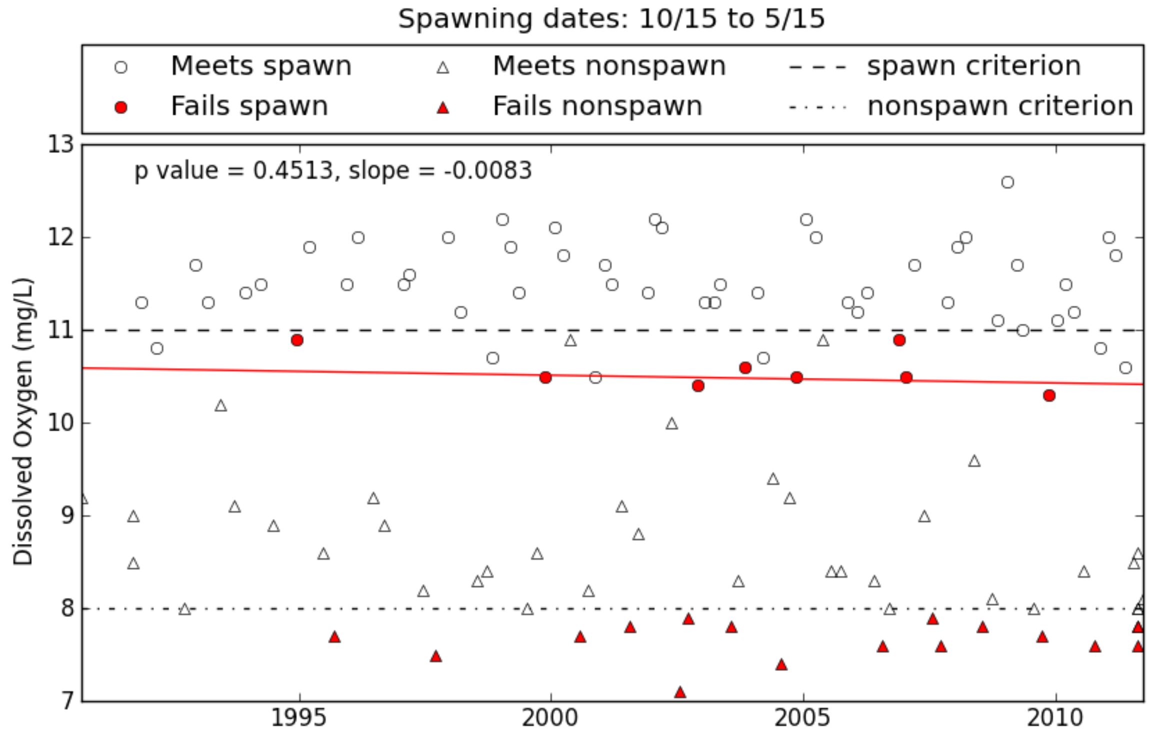


Figure 2- 7. South Fork Coquille River at Broadbent - dissolved oxygen (DEQ, 2014).

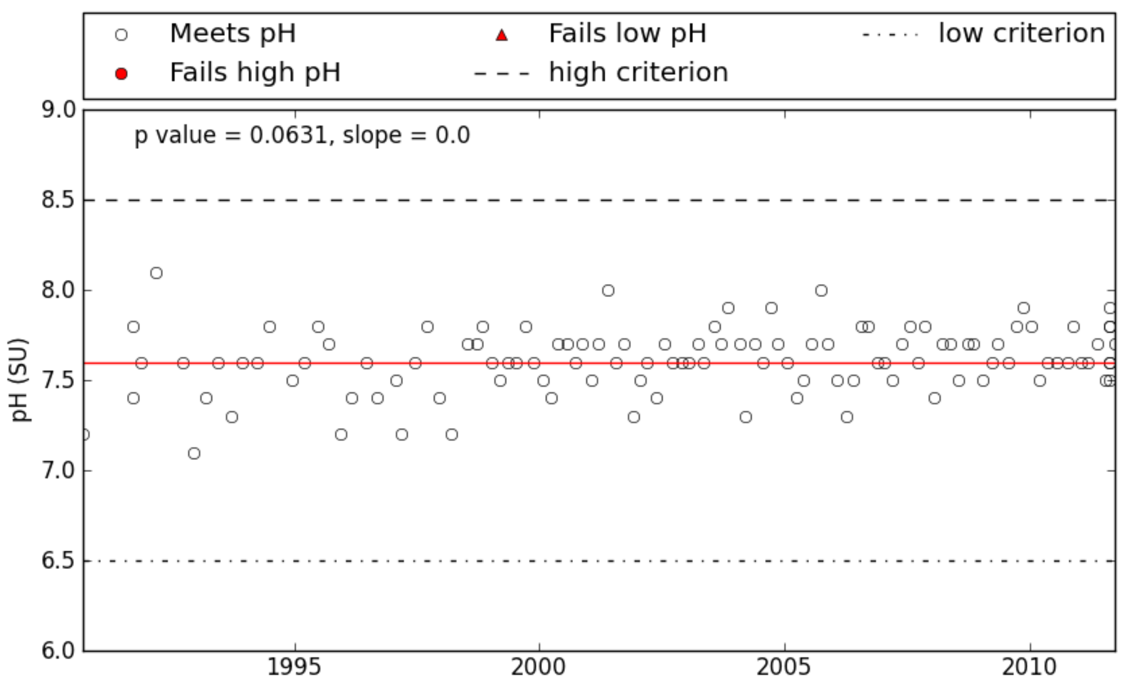


Figure 2- 8. South Fork Coquille River at Broadbent – pH (DEQ, 2014).

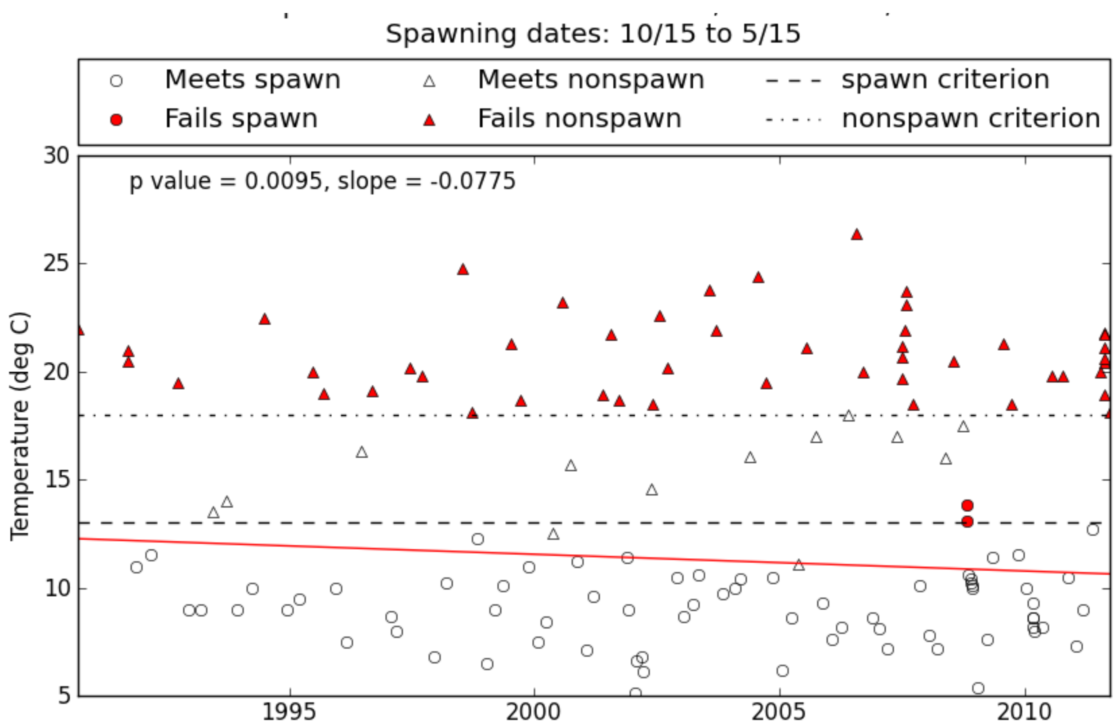


Figure 2- 9. South Fork Coquille River at Broadbent - temperature (DEQ, 2014).

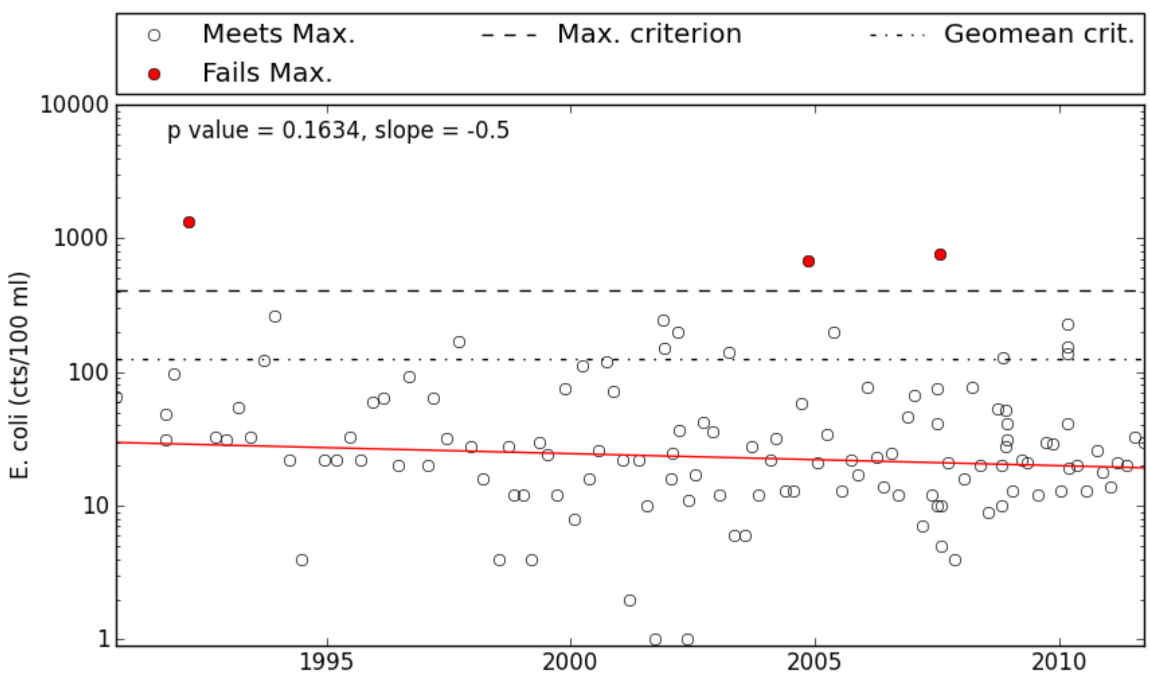


Figure 2- 10. South Fork Coquille River at Broadbent - bacteria (DEQ, 2014).

2.2.c. Water Quality Limitations and Total Maximum Daily Loads (TMDL)

The Clean Water Act requires the Department of Environmental Quality (DEQ) to periodically submit a water quality inventory report. The report is referred to as the Integrated Report. The Integrated Report provides information about overall water quality and the extent to which state waters provide for the designated beneficial uses. These beneficial uses include the protection and propagation of a balanced population of fish and wildlife, and allow recreational activities in and on the water. (DEQ, 2012b)

The Clean Water Act also requires the DEQ to identify state waters where existing pollution controls are not stringent enough to achieve state water quality standards. Where data show that a water body is not supporting water dependent beneficial uses studies must be conducted to determine the sources and quantities of pollutants affecting the water body and how those vary over time. This information is then used to support the development of Total Maximum Daily Loads (TMDLs). TMDLs describe the amount of each pollutant a water body can receive and not violate water quality standards. (DEQ, 2012b)

The Integrated Report includes information about areas where water quality standards or criteria are attained, where they are not attained, and where insufficient data exists to determine the status of the water quality. In some cases a determination is made that a designated beneficial use is not supported but a TMDL is not needed. For instance, flow and habitat modifications are identified as impairments to beneficial uses but the lack of flow and physical habitat are not considered to be pollutants. Adequate flow and habitat complexity are both parameters that affect stream temperatures so improving habitat complexity and increasing flows are strongly connected to achieving desired reductions in temperature. (DEQ, 2012b)

More information about the methodology that is applied to make these determinations can be found in the document; Methodology for Oregon’s 2010 Water Quality Report and List of Water Quality Limited Waters (DEQ, 2011a). Parameters like temperature and dissolved oxygen can be limiting to fish rearing and spawning and to other aquatic life and the parameter biological criteria is also considered limiting to aquatic life. The parameter *E. coli* is limiting to human water contact recreation. Invasive weeds and hazardous algal blooms in Sru Lake (USFS ownership in the upper portion of the watershed) are limiting to fish and aquatic life, fishing, boating, water contact recreation, and aesthetic quality.

Table 2-4 summarizes DEQ’s current understanding of the South Fork Coquille River’s water quality limited water bodies where total maximum daily loads need to be developed.

Table 2- 4. Integrated report of water quality limited bodies where a TMDL is needed (DEQ, 2012b).

Water Body (Stream/Lake)	River Miles	Parameter	Season	Beneficial Use
Baker Creek	0 to 2.9	Temperature	Summer	Salmonid Fish Rearing
Rowland Creek	0 to 4.6			
Salmon Creek	0 to 9.2			
Catching Creek	0 to 11.1			
S. Fk Coquille River	0 to 61.9			
S. Fk Coquille River	18.1 to 47.1		September 1 – June 15	Spawning
Lake Creek	0 to 0.9	Biological Criteria	Year Around	Aquatic Life
Mill Creek	0 to 2			
S. Fk Coquille River	0 to 51.9			
S. Fk Coquille River	53.4 to 61.9			
Ward Creek	0 to 3.3			
Mill Creek	0 to 2	Dissolved Oxygen	Year Around	Non-spawning
S. Fk Coquille River	0 to 18.1			
S. Fk Coquille River	4.7 to 18.1		October 15 – May 15	Spawning
S. Fk Coquille River	0 to 18.9	*E. coli*	Fall Winter Spring	Recreational Contact
Catching Creek	0 to 11.2			
Catching Creek	0 to 11.2		Summer	
Sru Lake	0 to 0	Aquatic Weeds Or Algae	Undefined	Recreational contact, Hazardous Algae Bloom

Please see Appendix B to access information about areas where water quality attains standards and criteria, areas where insufficient data exists to fully evaluate water quality conditions, and areas where flow and habitat modification have been identified as contributing to water quality limitations.

2.2.d. Upper South Fork Coquille River Temperature TMDL (DEQ, 2001).

The Upper South Fork Coquille River TMDL and Water Quality Management Plan (WQMP) for the parameter temperature was approved in 2001 and can be accessed at the DEQ's water quality website under Oregon Total Maximum Daily Loads (TMDLs) by basin. The WQMP identifies on the ground actions and monitoring that will be implemented by responsible parties.

The TMDL requires actions to limit thermal loading to surface water bodies. In general, TMDL loading capacities are expressed as pollutant loading limits plus a Human Use Allowance (HUA) for both point and nonpoint sources of pollution. The TMDL load allocations take the form of numeric loads (limits thermal loading units) as well as the surrogate to thermal loading units, percent effective shade targets. The water bodies assessed in the 2001 Upper South Fork Coquille River Temperature TMDL are shown in Table 2-5..

Table 2- 5. Water bodies assessed in the upper South Fork Coquille River, approved TMDL (DEQ, 2001).

Water Body (Stream/Lake)	River Miles	Parameter	Season
Johnson Creek	0 to 7.1	Temperature	Summer
Rock Creek	0 to 3	Temperature	Summer
South Fork Coquille River	42.1 to 61.9	Temperature	Summer
Johnson Creek	0 to 7.1	Temperature	Year Around (Non-spawning)

2.2.e. Fish and Aquatic Life Water Quality Limitation – Temperature

Salmonids, and some amphibians, are highly sensitive to temperature. In particular, spring Chinook and Coho Salmon are among the most temperature sensitive of the cold water fish species in the South Coast Basin. Oregon's water temperature criteria employ a logic that relies on using salmonid life cycles as the most sensitive indicator for the parameter temperature. Temperatures which protect these indicator species will also protect other species. Excessive summer water temperatures reduce the quality of rearing and spawning habitat for Chinook and Coho Salmon, steelhead, and resident trout (DEQ, 1995a).

Oregon Administrative Rules specify that, unless superseded by the natural conditions criteria or site-specific criteria, the temperature criteria for State waters supporting salmonid fishes are the applicable Biologically Based Numeric Criteria as seven-day average daily maximum stream temperatures. This is a moving average of consecutive 7-day period maximum temperatures. The criterion is applied to the 7-day period with the highest average stream temperatures. (Table 2-6)

The biologically-based numeric criterion for the South Fork Coquille River upstream of Yellow Creek during the summer non-spawning period is the 16.0°C core cold-water criterion. From September 15 through June 15, the biological criterion is the 13°C spawning criteria. (Table 2-6)

The designated fish use of the South Fork Coquille downstream of Yellow Creek is Salmon and Trout Rearing and Migration, for which the numeric criterion is 18°C. Salmon and steelhead spawning is not a designated fish use for this portion of the South Fork Coquille so 18°C is the biological criterion year-round. (Table 2-6)

When temperatures exceed these criteria (Table 2-6), there is stress to the salmonid species. Temperatures that can induce mortality in cold water fish are shown in Table 2-7.

Table 2- 6. South Fork Coquille River biologically based temperature criterion (Oregon Administrative Rule 340-41).

Month	Mouth to Yellow Creek and Tributaries	Yellow Creek to SFC River Falls and Tributaries*	Use - Salmon and Trout
7-Day Average Maximum			
Jan 1 – June 15	18.0 C/64.4 F	13.0 C/55.4 F	Spawning
June 15 – June 30	18.0 C/64.4 F	16.0 C/60.8 F	Rearing
July 1 – Sept 15	18.0 C/64.4 F	16.0 C/60.8 F	Rearing
Sept 15 – Dec 31	18.0 C/64.4 F	13.0 C/55.4 F	Spawning

*Lower Rock Creek spawning period October 1 – June 15, Lower Rock Creek tributaries spawning January 1 – June 15, Upper Rock Creek spawning October 15 – June 15.

Table 2- 7. Modes of thermally induced cold water fish mortality.

Modes of Thermally Induced Fish Mortality[1]	Temperature Range	Time to Death
Instantaneous Lethal Limit – Denaturing of bodily enzyme systems	> 90°F (> 32°C)	Instantaneous
Incipient Lethal Limit – Breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation	70°F - 77°F	(21°C - 25°C) Hours to Days
Sub-Lethal Limit – Conditions that cause decreased or lack of metabolic energy for feeding, growth or reproductive behavior, encourage increased exposure to pathogens, decreased food supply and increased competition from warm water tolerant species	64°F - 74°F	(20°C - 23°C) Weeks to Months

[1]Brett, 1952; Hokanson et al., 1977; Bell, 1986.

Continuous monitoring of stream temperature has been widely implemented in the South Fork Coquille River by DEQ and various partners. Large continuous datasets are managed to derive information relating to water quality criteria attainment, the magnitude of the temperature limitation, and to provide insight into priority areas for the implementation of projects to address stream warming.

DEQ collected South Fork Coquille River continuous temperature datasets during the summer of 2010. Longitudinal monitoring of the South Fork Coquille River and tributaries was conducted in order to better understand the temporal and spatial temperature regime of the river. Flows were also measured at most temperature monitoring locations in 2010. These locations can be found in Table 2-8.

Table 2- 8. South Fork Coquille River 2010 temperature monitoring site locations.

Site Name	Longitude	Latitude
South Fork Coquille River, RM 1.0, Myrtle Point boat ramp	-124.1474	43.0668
South Fork Coquille River at RM 2.80	-124.1469	43.0481
South Fork Coquille River at RM 4.8	-124.117	43.035
South Fork Coquille River at RM 6.9	-124.1371	43.0143
South Fork Coquille River 1M U/S Broadbent RM 10	-124.1472	43.0049
South Fork Coquille River at RM 16, Albert Powers State Park	-124.1326	42.9672
South Fork Coquille River at RM 19, Myrtle Grove State Park	-124.107	42.9484
South Fork Coquille River at RM 20.5	-124.1006	42.9399
South Fork Coquille River at RM 25, downstream of Baker Creek	-124.1114	42.9075
South Fork Coquille RM 27 1 Mile D/S of Powers STP	-124.0825	42.8971
South Fork Coquille River 50 ft. U/S of Powers Sewage Treatment Plant (STP) (RM. 28.5)	-124.0738	42.8846
South Fork Coquille RM 30 at Airport Road (Powers)	-124.0636	42.8756
South Fork Coquille RM 35 at U/S Forest Service Boundary	-124.0326	42.8323
Catching Creek at Bridge 34	-124.1521	43.0528
Middle Fork Coquille River at RM 0.2 at Hwy 42 (Hoffman State Park)	-124.1132	43.0329
Rhoda Creek at Hwy. 542	-124.1364	43.0141
Yellow Creek at Hwy 542	-124.0961	42.9501
Baker Creek at mouth	-124.111	42.906
Woodward Creek at Gant Creek Road	-124.0759	42.8995
Powers STP (final effluent)	-124.0674	42.8882
Mill Creek at Mouth	-124.0647	42.8764
Hayes Creek at Mouth	-124.0583	42.8733

Temperature Data Interpretation

Temperature 7-day average maximum assessments are designed to allow evaluation of data relative to the State of Oregon’s biologically based numeric temperature criteria. While this is an important area of focus, continuous temperature data sets can provide valuable information which will allow characterization of site thermal regimes. The derivation of this biologically pertinent information from temperature data is helpful in the characterization and quantification of management related changes in the thermal regime, is a useful tool to determine restoration priorities, and helps place temperature data in a context where fish stressors can be better quantified. The delta value (Δ) indicates the amount of change in stream temperature over each the day (diurnal fluctuation).

Metrics commonly derived from continuous temperature datasets include:

1. Seasonal maximum date and value
2. Seasonal minimum date and value
3. Seasonal maximum daily change (delta or Δ) in stream temperature date and value

4. 7-day average maximums date, 7-day average maximum and minimum values, and the 7-day average daily change (delta or Δ) temperature
5. Number of days when temperature exceeded 55, 64, and 70 degrees Fahrenheit
6. Number of hours when temperature exceeded 55, 64, and 70 degrees Fahrenheit

Temperature Data Metrics

Headwater sites tend to have lower daily temperature fluctuations or delta T (Δ or DT) values as well as do sites located low in the river. This is because headwater sites often stay cooler throughout the day and sites lower in the South Fork stay warmer throughout the day. Where DT's (Δ) are large the water is cool in the mornings and warms during the day. This can represent a good area to consider implementing riparian improvement projects.

The amount of time a site exceeds differing temperatures is also a valuable temperature metric. A site that has fewer temperature days over 64^{o} F and has no days where temperatures exceed 70^{o} F, a condition that can become lethal to fish, provides better habitat value than a site with more of the period of record over these values. The number of days a stream exceeds given temperatures is a good way to evaluate the cumulative temperature impacts on juvenile fish.

Changes to the temperature regime resulting from riparian management activities that increase solar loading can be analyzed at differing levels. Often temperature increases are first observable as decreases in the days and hours the water body spends in lower temperature ranges.

South Fork Coquille River 2010 Temperature Study Results

Figure 2-11 shows the water temperature monitoring sites and Tables 2-9 and 2-10 show the metrics derived by DEQ from these temperature data.

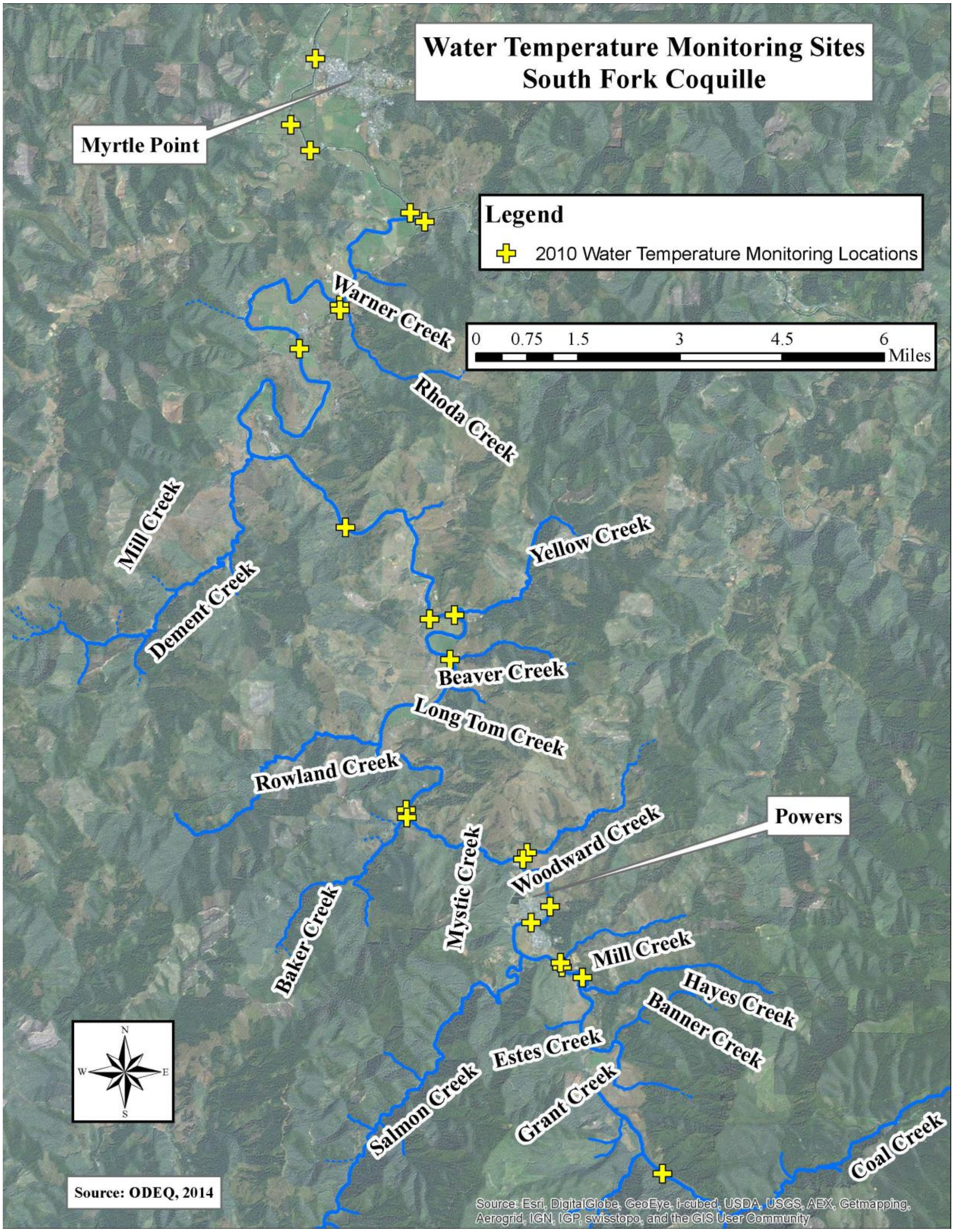


Figure 2- 11. South Fork Coquille River mainstem and tributary 2010 temperature monitoring sites.

Table 2- 9. South Fork Coquille River and tributary 2010 temperature metrics.

SFC RM and Tributary	Start Date	Stop Date	Seasonal Maximum		Seasonal Minimum		Seasonal Max Delta (Δ) T		7-Day averages			
			Date	Value	Date	Value	Date	Value	Date	Max	Min	ΔT
1.0	07/02	09/07	07/11	77.9	09/06	61.1	08/24	11.0	08/13	75.6	68.2	7.4
2.80	07/02	09/07	07/11	77.0	07/03	61.8	08/24	7.6	07/12	74.8	69.4	5.4
4.8	07/07	09/29	07/11	78.3	09/23	61.8	07/14	7.9	07/12	76.2	70.0	6.2
6.9	07/02	08/26	07/11	78.2	08/24	56.8	08/24	18.7	07/13	76.1	70.3	5.8
10	07/07	09/14	07/11	77.8	09/10	63.9	07/09	7.7	07/10	75.8	69.5	6.3
16	07/08	08/01	07/11	77.5	07/14	64.2	07/08	10.4	07/11	75.7	66.9	8.8
19	07/08	09/06	07/11	81.1	09/06	61.0	08/24	15.7	08/14	79.3	67.3	12.0
20.5	07/09	09/14	08/16	78.2	09/06	59.6	08/24	14.0	08/14	77.0	67.7	9.3
25	07/08	09/06	07/11	74.2	09/06	61.2	07/08	6.6	07/11	72.3	66.4	5.9
27	07/08	09/06	08/13	80.0	09/06	58.0	08/24	15.9	08/14	78.8	66.0	12.8
28.5	07/08	09/06	08/16	76.3	09/06	59.4	08/24	12.2	08/15	75.4	66.6	8.7
30	07/08	10/19	08/16	75.0	10/19	49.9	07/14	12.2	08/14	74.1	66.0	8.1
35	07/09	09/29	08/14	67.5	09/23	55.8	07/24	4.5	08/15	66.8	63.6	3.2
Catching	07/02	09/07	07/11	71.0	09/06	57.5	07/14	5.6	07/11	69.1	64.5	4.6
Middle Fork	07/07	09/14	07/11	75.3	09/12	61.5	08/24	7.8	08/13	73.9	68.1	5.8
Rhoda	07/07	07/26	07/11	66.9	07/19	55.2	07/24	9.3	07/12	64.6	57.9	6.7
Yellow	07/08	08/26	07/11	65.7	07/14	54.3	07/14	7.2	07/11	63.3	57.9	5.4
Baker	07/13	09/11	07/16	66.0	09/11	52.2	07/19	7.7	08/19	63.3	58.6	4.7
Woodward	07/08	08/26	07/09	72.6	08/23	54.1	07/08	12.7	07/11	69.8	59.6	10.2
Powers STP effluent	07/13	10/19	08/16	73.8	10/14	58.8	08/24	8.3	08/14	72.6	66.8	5.8
Mill	07/08	08/26	08/25	77.6	07/14	54.0	08/24	20.7	08/22	72.7	57.5	15.2
Hayes	07/08	08/26	07/11	62.7	07/14	51.9	07/14	6.9	08/14	61.1	57.5	3.6

When comparing Table 2-10 metrics between sites please note that the length of the period of record (number of days devices were deployed) is variable. Please refer to start and stop dates to determine direct comparability.

Table 2- 10. South Fork Coquille River 2010 temperature metrics continued.

SFC RM and Tributary	Days >	Days >	Days >	Hours >	Hours >	Hours >	Warmest day of 7-day max		
	55 F	64 F	70 F	55 F	64 F	70 F	Date	Max	Min
1.0	68	68	62	1632	1593	697	08/13	77.0	68.7
2.80	68	68	59	1632	1600	793	07/11	77.0	71.2
4.8	85	85	61	2040	1990	964	07/11	78.3	72.4
6.9	56	56	50	1344	1242	665	07/11	78.2	72.9
10	70	70	58	1680	1678	978	07/11	77.8	71.3
16	25	25	24	600	600	339	07/11	77.5	69.5
19	61	61	60	1464	1431	735	08/16	80.8	67.7
20.5	68	68	63	1632	1499	608	08/16	78.2	68.4
25	61	61	43	1464	1429	397	07/11	74.2	69.2
27	61	61	56	1464	1279	426	08/13	80.0	65.8
28.5	61	61	47	1464	1272	355	08/16	76.3	66.4
30	104	82	48	2412	1398	306	08/16	75.0	66.9

SFC RM and Tributary	Days >	Days >	Days >	Hours >	Hours >	Hours >	Warmest day of 7-day max		
	55 F	64 F	70 F	55 F	64 F	70 F	Date	Max	Min
35	83	42	0	1992	527	0	08/14	67.5	64.1
Catching	68	59	2	1632	765	9	07/11	71.0	66.2
Middle Fk	70	70	53	1680	1589	491	08/13	75.2	68.5
Rhoda	20	9	0	480	34	0	07/11	66.9	60.7
Yellow	50	3	0	1181	20	0	07/11	65.7	61.0
Baker	61	4	0	1426	13	0	08/18	64.1	58.5
Woodward	50	23	4	1195	159	22	07/09	72.6	60.3
Powers STP effluent	99	94	37	2376	2083	229	08/16	73.8	66.8
Mill Ck	50	44	13	1191	266	32	08/25	77.6	57.9
Hayes Ck	50	0	0	1126	0	0	08/13	61.5	57.0

DEQ has used this 2010 temperature dataset to calibrate a predictive model capable of determining temperature responses that might be expected if shade and flow increased and if channel width to depth ratios decreased.

Environmental Influences on Temperature

Stream temperature is influenced by natural factors such as climate, geomorphology, hydrology, and vegetation (Figure 2-12). Human or anthropogenic heat sources may include the discharge of heated water to surface waters, increases in the amount of sunlight that reaches the water's surface due to the loss of shade from streamside vegetation, changes to stream channel form, reductions in natural stream flows and channel complexity, and the reduction of cold water inputs from groundwater.

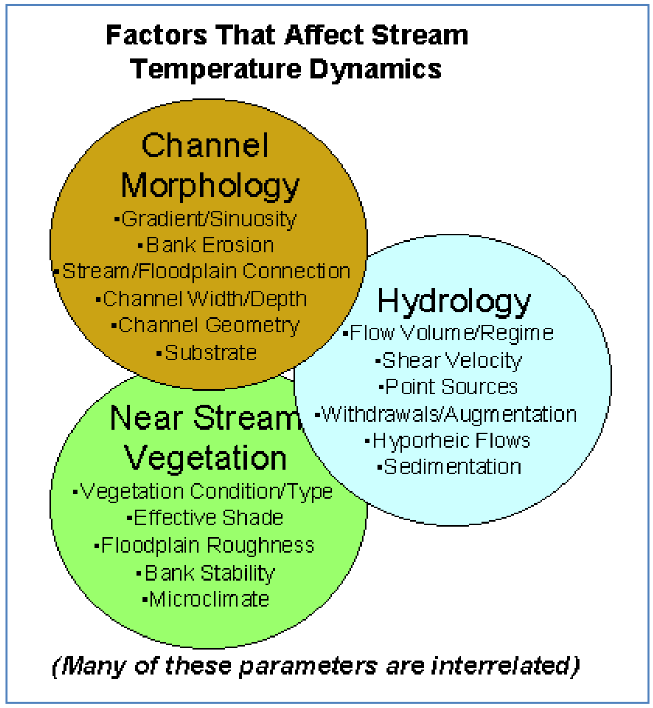


Figure 2- 12. Factors that affect stream temperature dynamics (Boyd and Kasper, 2003).

Anthropogenic activities that affect stream temperature can be grouped as near stream land cover (vegetation), channel morphology and hydrology. Many of these stream parameters are interrelated (i.e., the condition of one may impact one or more of the other parameters). Stream temperature dynamics are influenced by the transfer of heat from the air, heat from the streambed (bedrock conducts more heat than gravels), evaporation (liquid becoming vaporized), and both long and short wave radiation (solar energy).

The analytical techniques employed to evaluate stream temperature can be designed to include all of the parameters that affect stream temperature provided that available data and methodologies allow accurate quantification.

Figure 2- 13. Lack of riparian vegetation and widening of the stream channel (Clearwater BioStudies, Inc., 2003).

The amount of solar energy that actually reaches the surface of a stream is determined by many factors including the position of the sun in the sky, cloud cover, local topography, stream aspect, stream width, and streamside vegetation. Streams generally warm in a downstream direction as they become wider and streamside vegetation is less effective at shading the surface of the water. Also, the cooling influences of ground water inflow and the impact of smaller tributaries have less of an impact downstream as a stream becomes larger because the cool water is a smaller percentage of the total stream flow. Greater reach volumes are associated with a reduction in stream sensitivity to natural and human sources of heat. Heat energy delivered by sunlight hitting the surface of the water is a primary cause of stream heating (Figure 2-13). As the channel widens more surface area is available to intercept heat energy. Riparian shade is a primary mechanism for preventing the delivery of the sun's heat energy to the water column.

Stream Shading

Riparian vegetation along the stream provides shade on the stream channel that helps to regulate stream temperature thereby keeping the water cooler in the summertime. To examine existing shade and predict potential for improvements to shade within the channel and riparian area of the lower South Fork Coquille River and tributaries compared to historic potential, SHADOW modelling was conducted (Clearwater BioStudies, Inc., 2003). Clearwater BioStudies, Inc. (2003) examined 154 South Fork Coquille River mainstem and tributary segments, incorporating factors such as stream width and directional alignment, percent overhanging vegetation, the height of current shade-producing vegetation, historic or potential vegetation, channel slope, and the distance from shade trees to the channel. They also used types and sizes of stands of trees growing along the riparian areas utilizing their data and Follansbee (2002). The following is an excerpt from Clearwater BiosStudies, Inc. (2003). For a crosswalk of Clearwater BioStudies, Inc. (2003) reach names with reach names used in this report see Table 1-3.

> With the exception of the river reach surrounding Powers (SFC-7), riparian areas along the lower South Fork between the National Forest boundary and Rowland (i.e., reaches SFC-6 and SFC-8) appear to have the potential for supporting mature stands of conifers or mixed tree stands strongly dominated by conifers. The Powers reach itself supports predominantly mixed tree stands strongly dominated by hardwoods, as does the river

reach between Rowland and Gaylord (SFC-5). We consider mature stands of trees with something similar to the current balance of hardwoods and conifers to represent site potential vegetation along these two reaches. Riparian areas bordering the four study reaches of the South Fork below Gaylord (SFC-1 through SFC-4) are dominated by stands of hardwoods with very few conifers, wherever trees are present. Historical records (Benner, 1991) combined with existing riparian communities in relatively least-disturbed areas suggest that these lowermost four reaches have the potential to support mature stands of mixed hardwoods that include Oregon ash, big-leaf maple, Oregon myrtle, red alder and pockets of black cottonwood.

Results of our SHADOW modeling reflect that both existing and potential levels of stream shading vary considerably within the study area. For the mainstem South Fork, where both existing and potential shade levels were generally lower than those of the tributary streams, our model-based estimates ranged from 0 to 40% for existing shade and from 10% to 61% for potential shade (Figure 2-14). Estimates of the scope for improving shade conditions within individual modeled segments of the mainstem varied between 9% and 39% (see Section 5.1.d. - Stream Shading and Riparian Restoration to Improve Shading).

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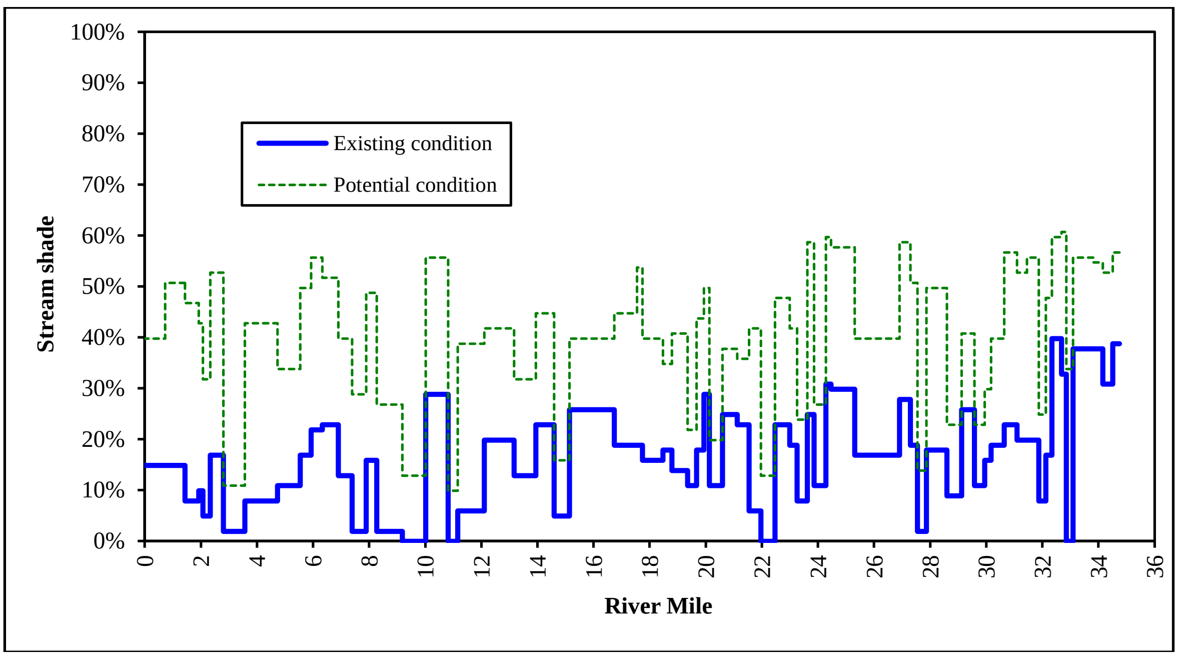


Figure 2- 14. Estimated levels of existing and potential stream shade, versus river mile, for the lower South Fork Coquille River, Oregon (Figure 19 in Clearwater BioStudies, Inc., 2003).

The following is an excerpt from Clearwater BiosStudies, Inc. (2003):

Differences between shade levels estimated for the lower South Fork mainstem and those estimated for the tributaries were substantial. This difference reflected both lower potential shade and what were typically greater levels of riparian disturbance along the mainstem.

> Streams or stream segments within the portions of the study area zoned for forest use tended to have greater existing and potential shade than did streams or segments in areas zoned for agricultural or rural residential use, although there were a few exceptions to this pattern. Despite their generally lower shade potentials, however, many segments zoned for agricultural or rural residential uses had greater scopes for improvement in shade conditions than did segments in forest areas.

Figure 2-15 shows a map of existing stream shade and Figure 2-16 shows a map of potential stream shade in the watershed. Subtracting existing shade from potential shade gives a scope for improvement. A map and further discussion of the scope for improvement is found in Figure 5-2 and in section 5.1.d. - Stream Shading and Riparian Restoration to Improve Shading. Patterns evident in the figures include (Clearwater Biostudies, Inc., 2003):

- Variable but low existing and potential shade levels along the mainstem South Fork Coquille.
- More variable but generally higher levels of existing shade along streams in the three tributary watersheds than along the mainstem South Fork Coquille. Estimated levels of existing shade varied from 22% to 95% among the 86 tributary reaches modeled.
- Consistently high shade potentials along all of the tributary streams. Estimated shade potentials varied from 86% to 95% among the 86 tributary reaches modeled.
- The presence of multiple east-west trending segments of the lower South Fork that have very low shade potentials related to high natural exposure to mid-summer sun.

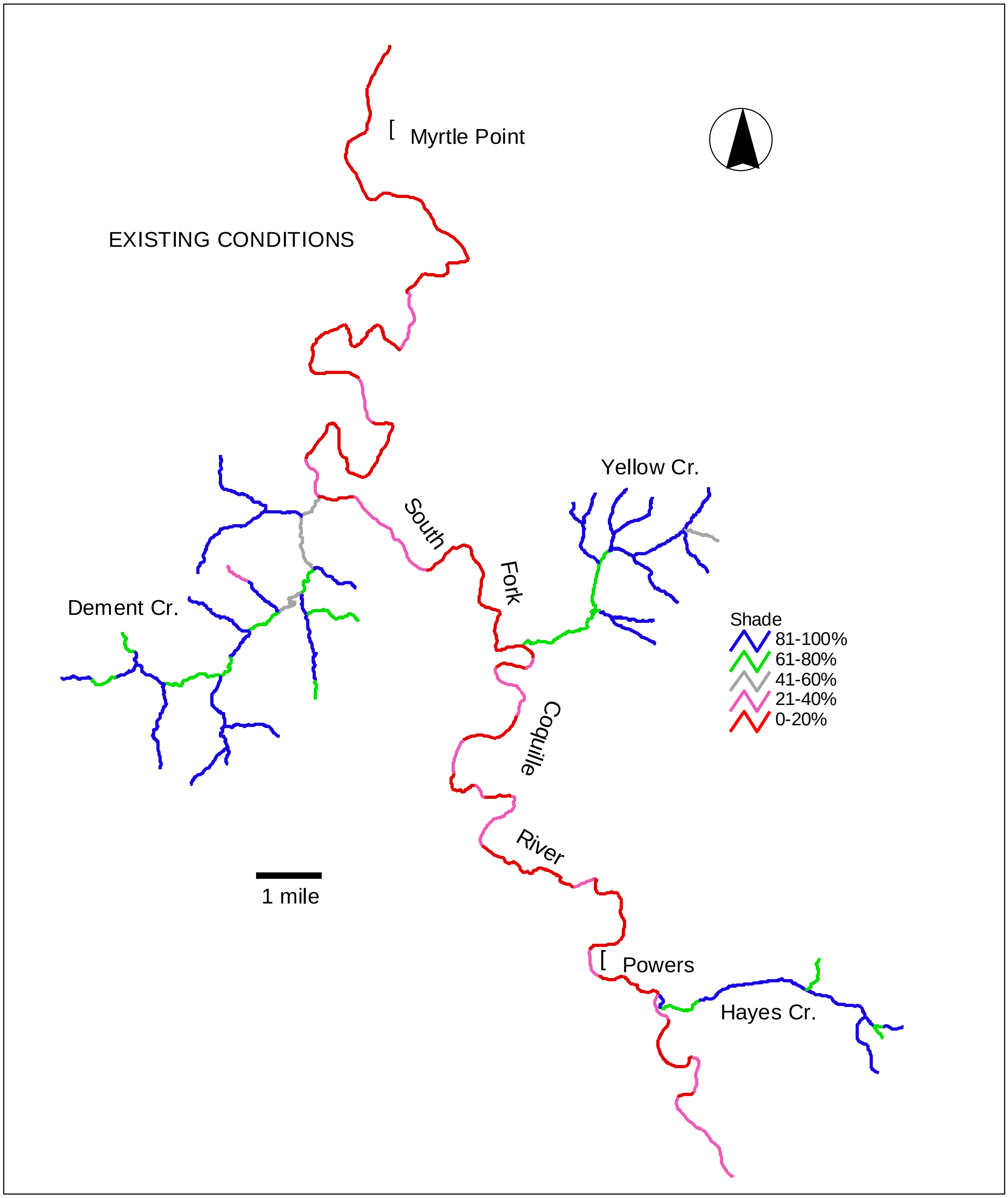


Figure 2- 15. Spatial variation in existing stream shade within the lower South Fork Coquille River study area (Figure 20 in Clearwater BioStudies, Inc., 2003).

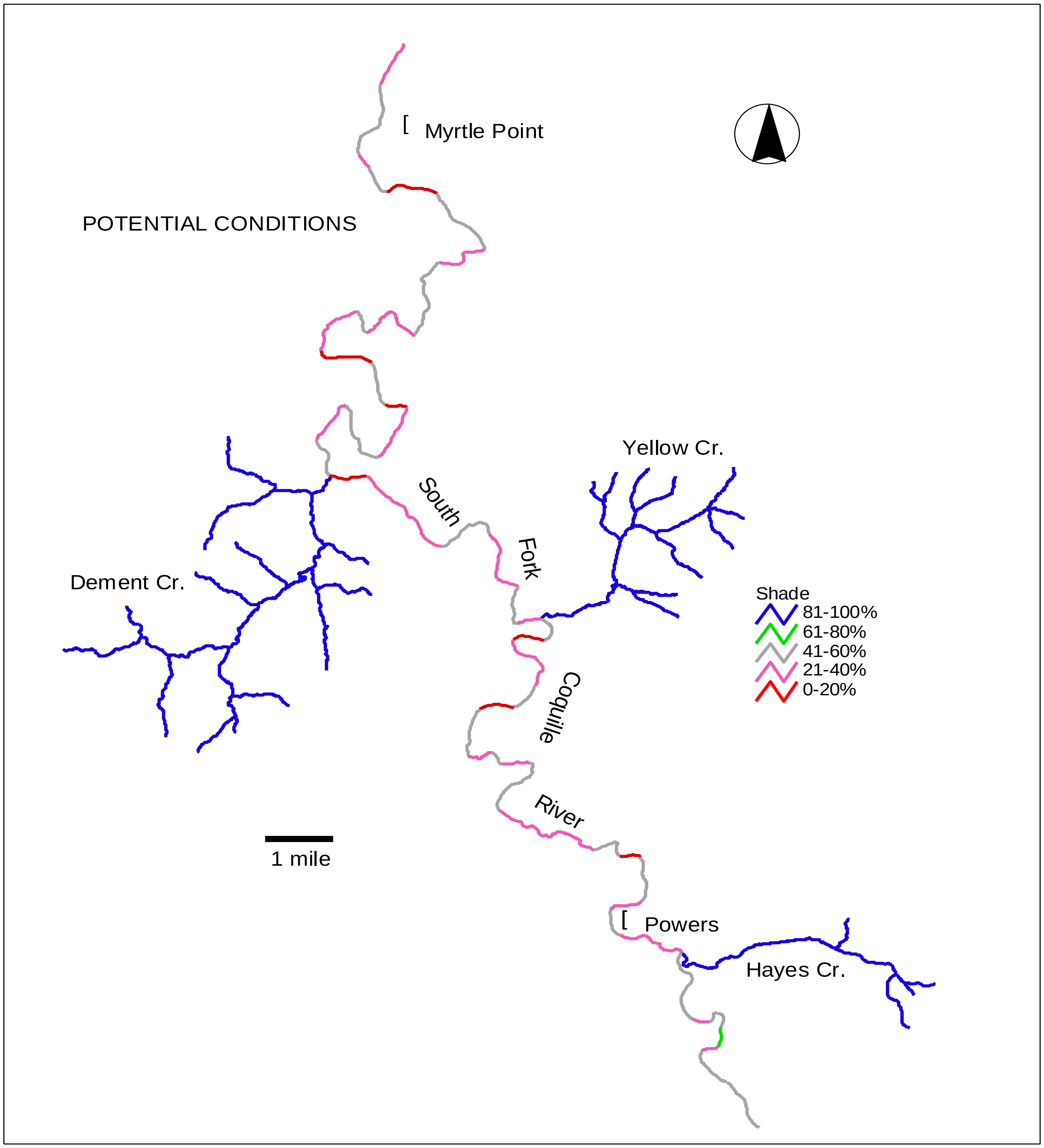


Figure 2- 16. Spatial variation in stream shade potential within the lower South Fork Coquille River study area (Figure 21 in Clearwater BioStudies, Inc., 2003).

The lower South Fork Coquille River temperature TMDL will target system potential effective shade, improvements in channel morphology (decrease in width to depth ratios), and instream flow augmentation as surrogate measures to meet the thermal load allocations for nonpoint sources. Point source thermal loading will be managed through an individual waste load allocation for the City of Powers sewage treatment plant (STP). Table 2-11 illustrates the results of the South Fork Coquille River shade assessment which determined current and potential shade values. The potential to improve shade is noted in the right hand column.

Table 2- 11. South Fork Coquille River existing and potential shade targets (Clearwater BioStudies, Inc., 2003).

Watershed	Current Shade	Target Effective Shade	Potential Shade Increase
Lower South Fork Coquille River (mainstem only)			
Forest	27%	45%	18%
Agricultural and Rural Residential Lands	15%	39%	24%
All	16%	40%	24%
Dement Cr. and tributaries			
Forest	85%	93%	8%
Agricultural and Rural Residential Lands	76%	90%	14%
All	83%	93%	10%
Yellow Cr. and tributaries			
Forest	91%	94%	3%
Agricultural and Rural Residential Lands	80%	92%	12%
All	87%	93%	6%
Hayes Cr. and tributaries			
Forest	84%	93%	9%
Agricultural and Rural Residential Lands	85%	92%	7%
All	84%	93%	9%

Cold Water Refugia

Elevated temperatures have been identified as a pollutant stressor adversely affecting fish and other aquatic life throughout the watershed. In areas where water temperatures exceed 70°F, the numbers of fish that can hold in cold water refugia for the warmest part of the day likely limit overall fish populations. DEQ defines "Cold-Water Refugia as those portions of a water body where or times during the diel temperature cycle when the water temperature is at least 2°C colder than the daily maximum temperature of the adjacent well-mixed flow of the water body." (OAR 340-041-0002 [10]).

The U.S. Environmental Protection Agency (EPA) has determined that "Critical aspects of the natural thermal regime that should be protected and restored include the spatial extent of cold-water refugia (generally defined as waters that are 2°C colder than the surrounding water), the diurnal temperature variation, the seasonal temperature variation (i.e., number of days at or near the maximum temperature), and shifts in the annual temperature pattern" (EPA, 2003).

2.2.f. Aquatic Life Water Quality Limitation - Biological Criteria (Macroinvertebrate Assemblages)

DEQ's biomonitoring program seeks to determine the relationship between water quality, habitat conditions and biological condition. Macroinvertebrate communities were sampled on small wadeable streams from 1998-2007 as part of the Environmental Monitoring and Assessment Program (EMAP) and the Oregon Plan for Salmon and Watersheds (OPSW). Predictive models were then applied to assess biological conditions and infer the level of impairment. Invertebrate conditions were evaluated through various random surveys of wadeable streams, and results provide an estimate of the status of compliance with the biocriteria requiring Oregon's waters to be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

Environmental Influences on Macroinvertebrate Communities

Information on optimal conditions for macroinvertebrate taxa were used to model potential causes of stress to macroinvertebrate assemblages. Using macroinvertebrates alone, DEQ inferred seasonal maximum temperature and percent fine sediments at a site. DEQ then made comparisons of inferred conditions at a site to inferred conditions observed at reference sites in the same ecoregion (DEQ, 2014). For more information on DEQ's Stressor ID models see the PREDATOR Model on the DEQ website. The sample size for the South Fork Coquille River is relatively small and additional information should be collected as resources allow.

There are currently 7 SFC segments identified for biocriteria impairments on the 2010 303d list of impaired waters (see Appendix B). The impairing pollutant in Lake Creek and Mill Creek is unclear. In 2010, the EPA determined a stream was impaired if data showed that there was a loss of greater than or equal to 15% of the types of aquatic insects in a taxonomic category when compared to the expected community in the Marine Western Coastal Forest (MWCF) region (Torgersen et al., 2012).

Temperature Stress

Seventy-five percent of the sites sampled in the South Fork Coquille River showed good condition for temperature stress, with no sites in fair condition (Table 2-12). About 25% of sites in the SFC showed poor conditions for temperature stress, meaning the macroinvertebrates at these sites can survive at higher temperatures than the macroinvertebrates at most reference sites.

Sediment Stress

Only 50% of sites were in good condition for fine sediment stress (Table 2-12). Excess fine sediments result in 13% of the sites being in poor condition and 38% in fair condition. Sites in fair condition may be indicating early signs of excess fine sediments. Shaded cells in the table below indicated that these sites are identified as impaired (303d listed) for the parameter biocriteria. In some cases the impairing stressor is not clear.

Table 2- 12. South Coast Basin invertebrate sample locations and conditions (DEQ, 2014).

Station	Site Name	Longitude	Latitude	Date	Temperature Score Condition	Fine Sediment Score Condition	PREDATOR Model Condition
33389	Crater Ck (ODFW)	-124.0666	42.7109	2006	Good	Good	Least Disturbed
25299	Dement Ck,	-124.2093	42.9416	2001	Good	Fair	Least Disturbed
23831	Johnson Ck @ RM 0.88	-124.0794	42.7554	2000	Good	Good	Least Disturbed
34700	Johnson Cr @ RM 3.43	-124.1172	42.7626	2007	Good	Good	Least Disturbed
33387	Salmon Ck (ODFW)	-124.1062	42.847	2006	Poor	Fair	Least Disturbed
25309	SF Coquille	-123.9838	42.7606	2001	Poor	Fair	Least Disturbed
30404	Upper Land Ck	-124.0448	42.8292	2003	Good	Fair	Least Disturbed
21799	Hall Ck @ RM 1.48	-124.0298	42.7682	2002	Good	Good	Most Disturbed
23830	Pyburn Ck @ RM 1.01	-124.1011	42.833	2000	Good	Good	Most Disturbed
34698	Lake Cr @ RM 0.16	-124.0645	42.7061	2007	Good	Good	Most Disturbed
21797	Mill Ck @ RM 1.30	-124.1882	42.9744	2005	Good	Fair	Most Disturbed

Station	Site Name	Longitude	Latitude	Date	Temperature Score Condition	Fine Sediment Score Condition	PREDATOR Model Condition
20392	SF Coquille 200 feet D/S of Powers STP	-124.0673	42.8888	2005	Poor	Fair	Most Disturbed
20394	SF Coquille 50 feet U/S of Powers STP	-124.0674	42.8881	2005	Poor	Good	Most Disturbed
23834	SF Coquille @ RM 55.5	-123.9473	42.7884	2000	Good	Good	Most Disturbed
33381	Ward Ck (ODFW)	-124.2359	43.0427	2006	Good	Poor	Most Disturbed
34675	Ward Cr @ RM 2.55	-124.2382	43.0394	2007	Good	Poor	Most Disturbed

2.2.g. Fish Impacts From Sedimentation and Turbidity

Sediment

Sediments in the water column reduce light penetration, increase water temperature, and modify water chemistry. Re-deposited sediments partly or completely fill pools, reduce the width to depth ratio of streams, and change the distribution of pools, riffles, and glides. Increased fine sediments in substrate also reduce survival of eggs and fry, reducing spawning success of salmon and steelhead.

Sediment input to stream channels is a result of both natural and management related processes. Primary sediment sources include episodic landslides, debris flows usually associated with intense winter storms (Townsend et al., 1977), hill slope erosion, stream bank erosion, and roads.

The stream geology, hydrology, and vegetation regulate frequency and relative importance of mass erosion processes. The Klamath range, which contains clay-rich bedrock and deep, cohesive soils often exhibit slow mass movement of creep or slump–earthflow (where the upper portion moves by slumping and the lower portion moves by flow). The Oregon Coast Range typically has mass erosion such as debris avalanches due to the steep slopes cohesionless soils and relatively competent bedrock.

Forest management related increases in sedimentation are most often the result of poorly designed and/or poorly maintained forest roads. These roads can be a major contributor of fine sediment to streams (Reid and Dunne, 1984). Natural surface and rocked roads with erosion, inadequate drainage, inadequate stream crossings, or unstable cutbanks and fill slopes have the potential to contribute sediment to stream channels. Some roads with these conditions can contribute sediment to fish bearing streams where there is a connection between the road and the stream channel. Some streams in the South Fork Coquille Watershed have been subject to episodic and/or chronic fine sediment input due to poor road design and lack of maintenance. Properly designed, surfaced, and maintained roads do not contribute sediment to stream channels. Roads with proper drainage features such as cross drains direct sediment laden water from the roads onto forest soils and not directly into streams.

A suitable composition of stream gravel is essential for successful salmonid and lamprey spawning. The size of gravel necessary depends on fish size, “large fish can use larger substrate materials than can small fish” (Meehan, 1991). Substrate for anadromous salmon and trout spawning should range from 1.3 to 10.2 cm. in diameter (Meehan, 1991). Successful incubation of eggs to the emergence of fry depends on many factors including the substrate composition and the amount of fine sediment (Meehan 1991). A redd relatively free of fine sediment results in proper water circulation through the gravel to supply oxygen and allows movement of alevins. Deposition of fine sediment in redds can reduce survival (Meehan, 1991) by reducing inter-gravel oxygen, preventing the flushing of biological waste, and preventing embryos from emerging.

Turbidity

Suspended sediments can be quantified using a measure of turbidity that measures the penetration of light into water. Increased suspended sediments have been known to adversely affect Coho Salmon behavior, physiology, and cause death.

Natural turbidity contributions occur from gully, and channel erosion and mass wasting (landslides), the deposition of organic materials or dust into waterways, and groundwater (nutrient) influences. Vegetation absence or loss from natural attrition, windthrow, fire, and/or seismic events, along with precipitation (or wind) events can increase soil erosion and contribute to hydraulic (or airborne) transport of turbidity-causing sediments into waterways. (DEQ, 2010)

The quality of landslide (or debris flow) materials from steeper, unlogged headwater areas tends to be a mix of wood, rock, and soil. The wood and rock in the system can create sediment traps, and build channel complexity that reduces hydraulic impacts to the channel bottom and walls, and attenuate or prevent downstream effects from sediments that might otherwise cause increasing turbidity and further erosion. (DEQ, 2010)

Natural levels of sedimentation and turbidity may be increased from historic times in channels where systems have been modified such that wood and complexity have been removed from channels or prevented from entering channels, or where wetlands and channel-adjacent braided channels and have been filled or cut off from the main channel. Flow connectivity with the floodplain and wetlands is also important in removing or filtering sediments and turbidity from the main channel. (DEQ, 2005b)

Organisms that form the base of the food chain are called primary producers. These organisms directly influence food available for invertebrates and fish. Increased turbidity has been shown to influence aquatic primary production by decreasing available light to plants. Increased turbidity can influence the presence and diversity of invertebrate species directly or through indirect adverse impacts on primary productivity. (DEQ, 2005b)

Direct turbidity effects to fish are mostly visibility-related, causing behavioral changes with respect to maneuverability or migration, feeding, predation, and/or escape. Behavioral effects could lead to use impairment through physiological or population effects by reduced or less efficient feeding leading to reduced growth, avoidance and habitat abandonment, interspecific competition, or other effects. Indirect effects to fish include foodchain impacts discussed above with respect to reductions in primary and secondary productivity including macroinvertebrate densities. (DEQ, 2005b)

Berg and Northcote (1985) describes effects on Coho Salmon resulting from a 4-hour exposure of suspended sediments with turbidity values of 20 to 30 nephelometric turbidity units (NTUs) as: (1) altered behavior (i.e. visual, reduced feeding, and loss of territoriality); (2) reduced feeding success (i.e. reduction in percent of prey captured, reaction distance to prey, and prey capture success); and (3) and physiological effects (i.e. gill flaring which indicates sediment in the gills resulting in gill trauma). In addition, at these turbidity levels, Coho Salmon exhibit avoidance behaviors (Servizi and Martens, 1991, Sigler et al., 1984; and Berg, 1983) and are reasonably certain to be displaced.

2.2.h. Fish and Aquatic Life Water Quality Limitation – Dissolved Oxygen

Adequate concentrations of dissolved oxygen (DO) are important for supporting fish, invertebrates, and other aquatic life. Some aquatic species, such as the salmonids, are very sensitive to reduced concentrations of dissolved oxygen. The level of dissolved oxygen needed to support the life stages of aquatic organisms varies and can generally be associated with specific seasons. For example, the early life stages of salmonids, typically occurring during late fall to early spring; require higher oxygen levels than other life stages. Other fish and invertebrates have similarly variable needs depending on life stages. (DEQ, 1995b)

Adequate intergravel dissolved oxygen levels are needed for developing embryos in salmonid redds, where they lay their eggs. The intergravel dissolved oxygen can vary based upon several factors including surface water dissolved oxygen concentrations, the percentage of fine sediment in gravels, sediment oxygen demand, and the oxygen demand of the eggs. Less oxygen is needed at higher stream velocities. Direct measurement of intergravel dissolved oxygen levels is challenging but is the best measure of the potential impacts on the embryos. For cold-water dependent early fish life stages, reductions in dissolved oxygen may result in mortality or reduced size of emerging juveniles. For other life stages of cold-water fish and aquatic life the sub lethal effects of reduced dissolved oxygen can include reduced swim speed and growth, food conversion efficiency, and mortality of sensitive invertebrates may occur. Juvenile salmonids exhibit avoidance behavior, selecting areas of higher oxygen concentration. Dissolved oxygen levels often vary diurnally due to changes in temperature, photosynthesis, and respiration. The minimum dissolved oxygen levels that occur in a daily cycle are important in determining effects to the aquatic community (DEQ, 1995b).

Table 2-13 explains the State dissolved oxygen (DO) criteria and applicable use/level of protection.

Table 2- 13. South Fork Coquille River dissolved oxygen (DO) criteria (Oregon Administrative Rule 340-41).

Class	Concentration and Period[1] (All Units are mg/L)				Use/Level of Protection
	30-D	**7-D**	**7-Min**	**Min**	
Salmonid Spawning		11.0[2,3]		9.0[3] / 8.0[4]	Principal use of salmonid spawning and incubation of embryos until emergence from the gravels. Low risk of impairment to cold-water aquatic life, other native fish and invertebrates.
Cold Water	8.0[5]		6.5	6.0	Principally cold-water aquatic life. Salmon, trout, cold-water invertebrates, and other native cold-water species exist throughout all or most of the year. Juvenile anadromous salmonids may rear throughout the year. No measurable risk level for these communities.

Note: *Shaded* values present the absolute minimum criteria, unless the Department believes adequate data exists to apply the multiple criteria and associated periods.

[1] 30-D = 30-day mean minimum as defined in OAR 340-41-006. 7-D = 7-day mean minimum as defined in OAR 340-41-006. 7-Min = 7-day minimum mean as defined in OAR 340-41-006. Min = Absolute minimums for surface samples when applying the averaging period, spatial median of IGDO.

[2] When Intergravel DO levels are 8.0 mg/L or greater, DO levels may be as low as 9.0 mg/L, without triggering a violation.

[3] If conditions of barometric pressure, altitude and temperature preclude achievement of the footnoted criteria, then 95 percent saturation applies.

[4] Intergravel DO criterion, spatial median minimum.

[5] If conditions of barometric pressure, altitude, and temperature preclude achievement of 8.0 mg/L, then 90 percent saturation applies.

According to DEQ, improvements in dissolved oxygen conditions should be realized as a result of implementing Temperature TMDLs. As stream temperatures decrease, the amount of oxygen that can remain dissolved in water increases and the amount of oxygen consumed by biological processes decreases. Photosynthetic processes can result in large shifts in pH and DO throughout the day and measures designed to reduce nutrient loading will be necessary to reduce diurnal fluctuations caused by instream algal and periphyton community photosynthesis (EPA, 2000).

Dissolved Oxygen (DO) Deficit

Because South Fork Coquille River grab samples indicated DO impairment ODEQ initiated intensive monitoring in 2007 and 2011 to better characterize temporal and spatial variability of the parameters dissolved oxygen and pH. Three day continuous water quality studies were conducted and dissolved oxygen, conductivity, and pH were recorded continuously at 15 minute intervals at four locations. Nutrient samples were also collected in conjunction with intensive monitoring and from significant tributaries and these data will be useful for the derivation of nutrient load reductions that may be required to meet surface water DO criteria. Nutrient data are not presented here but can be made available by contacting DEQ. (DEQ, 2014)

DO deficit was calculated for sites where these continuous data sets were available (Table 2-14). The percent saturation of DO in water is derived by applying factors to equalize values for water temperature, elevation, and barometric pressure. When there are no oxygen demanding substances or algal activity present, oxygen saturation values would be at 100%. (DEQ, 2014)

The antidegradation rule, OAR 340-041-0004, states that up to a 0.1 mg/l decrease in DO from the upstream end of a stream reach to the downstream end of the reach is not considered a reduction in water quality so long as it has no adverse effects on threatened and endangered species. The evaluation of DO deficit can provide insight into the presence and magnitude of oxygen demanding substances and their impact on water column DO levels.

DO deficit represents the sum total of biochemical impacts on DO. For example, if a wastewater treatment plant effluent had a biochemical oxygen demand of 1 mg/L, and it were all exerted at once, dissolved oxygen values in the receiving water body would be reduced by 1 mg/L. DO deficit is derived by subtracting saturation DO values from DO values measured in the stream. Saturation DO is derived by dividing measured DO levels by calculated percent saturation to determine what water column DO would be if fully saturated at the same location, elevation, temperature, and barometric pressure.

Where algal activity is present, oxygen is produced and may reduce DO deficits resulting from biochemical demand. DO deficits may be decreased downstream as photosynthetic processes produce oxygen. This may be in part causal of the lesser DO deficit downstream of the City of Powers sewage treatment plant.

Table 2- 14. South Fork Coquille River dissolved oxygen (DO) deficit (DEQ, 2011b).

LASAR Number	Site Name	Average DO Deficit (mg/L)
20394	SF Coquille River 50’ U/S of WWTP Outfall	0.8
34447	SF Coquille River 1 Mile D/S of WWTP Outfall	0.3
36253	SF Coquille River U/S Hayes Bar Boat Launch	0.8
25760	SF Coquille River @ Myrtle Grove State Park	1.1

Dissolved Oxygen and pH Diel Fluctuation - Photosynthetic Processes

Excessive growth of photosynthesizing organisms can result in significant diel fluctuations in DO and pH which may adversely impact aquatic life and result in water quality standards violations. This growth can be observed in streams as: periphyton (attached diatom and algae assemblages), phytoplankton (algae and other small organisms which are suspended in the water column), and macrophytes (large rooted vascular plants, mosses, liverworts, and periphyton - such as long filaments of the green alga).

During the day, when macrophytes and algae photosynthesize and grow, carbon dioxide is consumed and oxygen produced. At night respiration dominates. Respiration occurs at a relatively constant rate both day and night and consumes oxygen and produces carbon dioxide. Respiration increases the hydrogen ion concentration, and consequently lowers the pH. Therefore, during the day, as algae consume carbon dioxide, pH increases; while at night, as algae produce carbon dioxide, pH declines. (DEQ, 2000)

Studies of diurnal fluctuation of DO were completed from 2007-2011. There studies showed the daily mean, diurnal fluctuation, and maximum percent saturation and average hours over 100% saturation. Although daily mean dissolved oxygen levels meet the salmonid rearing criteria, the other information provides a picture of the stresses to the salmonids. The DEQ is in progress of compiling these data. For more information contact the DEQ Coos Bay office.

2.2.i. Human Health Water Quality Limitation – Bacteria and Other Pathogens

Water contact recreation and public and private drinking water supply are beneficial uses sensitive to pathogenic organisms, including bacteria. In Oregon, *Escherichia coli* (*E. coli*) and fecal coliform are used as indicator organisms for assessing impairment in fresh waters. (DEQ, 2012a)

Bacterial loading due to runoff was evaluated by collecting bacterial samples in conjunction with rainfall events during both rising and falling flow conditions. Table 2-15 summarizes bacterial data and shows the percent reduction in bacterial levels needed to meet both the recreational contact log mean criteria (log mean of 126 colonies/100mL with a minimum of five samples) and the single sample bacterial maximum criteria (no single sample over 406 colonies/100mL). Sites with less than five data points are also summarized in order to present the limited data available and the number of samples considered is shown as N.

Table 2- 15. South Fork Coquille River recreational contact bacterial summary.

River Mile	Station Description	Log Mean *E. coli*/N	Maximum *E. coli*	%Reduction Log Mean/Max
1	SF Coquille River	82/28	980	0/59
Trib. @ RM 2	Catching Creek at Bridge 34	356/26	4884	64/92
4.8	South Fork Coquille River	77/11	1414	65/71
10	South Fork Coquille River	28/130	1274	0/68
16.5	SF Coquille River	36/24	1733	0/77
19	SF Coquille River	26/20	238	0/0
25	SF Coquille River	24/25	1203	0/66
26.7	SF Coquille River 1 mi. D/S of Powers STP	50/26	1120	0/64
31.5	South Fork Coquille River	11/25	83	0/0

The Powers Sewage Treatment Plant (STP) suffers from inflow and infiltration as well as treatment plant inadequacies which result in the bypass of partially treated effluent during storm events. This facility is in the process of planning and funding an infrastructure upgrade to alleviate these problems. This small city discharges relatively small volumes when compared to flows in the receiving water body and bacterial loads downstream of the STP are comprised of STP effluent, natural background, and non-point sources. Analyses indicate that even without contributions from the STP, significant bacterial reductions are needed from non-point sources to support safe recreational contact.

2.2.j. Human Health - Public Water Supply

The 1996 amendments to the federal Safe Drinking Water Act included funding for public drinking water supply system improvements to meet existing and future human health standards, identify public drinking water supply source areas and inventory potential contamination sources. A primary goal of the amendments was to help reduce the risk of pollution to public water systems, including contamination that could potentially result in loss of the drinking water resource (DEQ, 2014).

Note that this section only addresses drinking water issues identified for public water systems. A recent query of Oregon Water Resources Department's water rights database for private domestic points of surface water diversion (using a threshold of 0.005 cfs for domestic water rights that are household use only, not irrigation) identified 931 private domestic water rights in the South Coast Basin. The quality of drinking water supplied by these private drinking water systems is not regularly monitored. There are also numerous private groundwater wells for domestic use as well. DEQ hears regularly from individuals with concerns regarding the impacts of land development and pesticide applications on privately owned and operated drinking water systems.

Drinking Water Source Water Assessment

DEQ and the Oregon Health Division (OHD) completed a Source Water Assessment to identify the surface areas that supply water to Powers' public water system intake and to inventory the potential contaminant sources that may impact the water supply (DEQ, 2003c). Powers' drinking water is drawn from two sources, Bingham Creek and the South Fork Coquille River. The Source Water Assessment was completed for the intake on the South Fork Coquille River.

This public water system serves approximately 700 citizens. The geographic area providing water to Powers' intake (the drinking water protection area) extends upstream approximately 32 miles in a southeasterly direction and encompasses a total area of approximately 147 square miles. The primary intent of this inventory was to identify and locate significant potential sources of contaminants of concern (DEQ, 2003c).

The delineated drinking water protection area is primarily dominated by public forest land uses. The potential contaminant sources identified in the watershed include: a water treatment plant, a former concrete plant, logging company, rural homesteads, grazing animals, non-irrigated crops, a park, river recreation/campgrounds, clearcuts, road density, stream crossings, an airport, and wildlife (DEQ, 2003c). These potential sources of contamination could, if improperly managed or released, impact the water quality in the watershed.

The sensitive areas within the Powers' drinking water protection area include areas with high soil permeability, high soil erosion potential, high runoff potential and areas within 1000 feet from the South Fork Coquille River and tributaries located above the drinking water intake. The sensitive areas are those where the potential contamination sources, if present, have a greater potential to impact the water supply. The information in the Powers Source Water Assessment provides a basis for prioritizing areas in and around the community that are most vulnerable to potential impacts and can be used by the Powers community to develop a voluntary Drinking Water Protection Plan (DEQ, 2003c).

A total of 12 potential contaminant sources were identified in Powers drinking water protection area. All of these sources are located in the sensitive areas and eleven are high to moderate risk sources within sensitive areas.

Safe Drinking Water Act Monitoring

Monitoring conducted according to the Safe Drinking Water Act indicates that City of Powers and Daphne Grove Camp Ground water systems have experienced contamination problems in finished water (Table 2-16).

Table 2- 16. Compounds detected above action levels* for South Fork Coquille River public water systems (pws).

Water Type	Analyte Name	PWS ID	PWS Name	Popula-tion	Count of Detects	Min of Concentra-tion mg/L	Max of Concentra-tion mg/L
Surface Water	Di(2-Ethylhexyl) Phthalate	672	City of Powers	750	1	0.0009	0.0009
Ground Water	Coliform (TCR)	92706	USFS Daphne Grove Camp Ground	48	1	1	1

Source: Oregon Safe Drinking Water Information System (SDWIS) Database SDWIS: January 1, 2000 through July 5, 2011.

Table 2-16 includes summary of detections above an action level. In general, the action level for volatile and synthetic organic compounds (VOCs and SOCs) is concentration > 0. Action level for coliform, *E. coli* and fecal concentration is >0 in a repeat sample.

Some people who drink water containing di(2-ethylhexyl) phthalate in excess of the maximum allowable contaminant level (MCL) over many years may have problems with their liver, or could experience reproductive difficulties and may have an increased risk of getting cancer (40CFR Part 141, Subpart Q, Appendix A).

The greatest use of di (2-ethylhexyl) phthalate is as a plasticizer for polyvinylchloride (PVC) and other polymers including rubber, cellulose and styrene. A number of packaging materials and tubings used in the production of foods and beverages are polyvinylchloride contaminated with phthalic acid esters, primarily di (2-ethylhexyl) phthalate.

In addition, turbidity or suspended fine sediment has been problematic for the City of Powers triggering temporary closure (DEQ, 2014). Elevated turbidity often results in increased back flushing and additional chemicals in the treatment process, thus increasing overall treatment costs to the public water systems and communities. Because of the need for more chemical addition elevated organic matter in raw water is often associated with the formation of disinfection byproducts during the drinking water treatment process. In addition, contaminants adsorbed to the surface of entrained particles in turbid water can also pose a threat.

2.2.k. Fish and Aquatic Life - Water Column Contaminants

As part of the 2009 Oregon Plan Coastal Coho Study, DEQ collected water samples for the analyses of 123 pesticide compounds at eight South Coast Basin ambient monitoring sites. This was the first South Coast Basin broad based screening for pesticides in surface waters. (Table 2-17)

Atrazine was the most widely detected pesticide and was present in five of the eight sites sampled. Atrazine is a selective triazine herbicide used by the agricultural and forest products industries as well as in residential settings to control broadleaf and grassy weeds. The EPA estimates the aquatic ecosystem level of concern as approximately 10 parts per billion (ppb) for atrazine over a 60-day period. Atrazine levels detected during South Coast Basin 2009 monitoring efforts are well below this threshold. The registration review for Atrazine, EPA's periodic re-evaluation program for existing pesticides, began in mid-2013. During this review new research will be considered to ensure that the current level of concern is protective of public health and the environment.

Table 2- 17. 2009 pesticide sampling stations in the South Fork Coquille Watershed.

LASAR Number	Site Name	Compounds Detected	Concentration (parts per trillion)	EPA Estimated Aquatic Ecosystem Level of Concern (parts per trillion)
11486	South Fork Coquille River @ Broadbent	Atrazine	4.2	10,000

2.3 Contemporary Anthropogenic Impacts, Effects on Fish, and Practices in Place to Minimize Impacts

2.3.a. Agricultural Management / Practices

Agriculture is a very important industry to our community and our nation's economy. While there are many methods of sustainable and responsible agriculture, if improperly managed, agricultural practices can have negative impacts on water and soil quality.

2.3.a.i. Agricultural Water Quality Impacts

Certain agricultural practices may elevate concentrations of nutrients, fecal coliforms, and sediment loads. Increased nutrient loading from animal waste can then lead to eutrophication of water bodies which may eventually damage aquatic ecosystems (USU, 2013). Animal waste introduced into waterways by livestock may also introduce toxic fecal coliforms which threaten public health (USU, 2013). Grazing and other agriculture practices may intensify erosion processes by raising sediment input to nearby water sources (USU, 2013). Increased sediment loads make drinking water treatment more difficult while also affecting fish and macro invertebrates (USU, 2013). The primary agricultural water quality concerns in the Coos-Coquille area and a brief summary of their associated impacts are as follows (ODA, 2013):

- Algae and aquatic weeds
  - High nutrient concentrations, eutrophication, from improper use of fertilizer or increased manure along a waterbody can lead to excessive growth of algae (University of Minnestota, 2014). Algae use dissolved oxygen to fuel night-time growth, when sunlight is unavailable for photosynthesis. When dissolved oxygen levels fall beneath certain levels, fish and other aquatic creatures suffer negative impacts and in extreme cases, may no longer be able to survive (CWEP, 2013).

- Bacteria
  - Bacteria can cause harmful infectious diseases among fish populations as well as endangering the human population.

- Chlorophyll a
  - Elevated chlorophyll a levels indicate high numbers of phytoplankton and free floating macro algae (see algae and aquatic weeds, above).

- Dissolved oxygen (DO)
  - Adequate concentrations of dissolved oxygen in freshwater streams are critical for the survival of salmonids. Fish have evolved very efficient physiological mechanisms for obtaining and using oxygen in the water to oxygenate blood and meet their metabolic demands (WDOE, 2002). Reduced levels of dissolved oxygen can impact growth and development of different life stages of salmon, including

eggs, alevins, and fry, as well as the swimming, feeding, and reproductive ability of juveniles and adults. Such impacts can affect fitness and survival by altering embryo incubation periods, decreasing the size of fry, increasing the likelihood of predation, and decreasing feeding activity. Under extreme conditions, low DO concentrations can even be lethal (Carter, 2005). Water temperature and DO available in the water is inversely proportional (as temperature increases, DO decreases). (See Section 2.2.h and Table 2-13 for more information.)

- Habitat modification
  - Impacts may include decreased refugia for juveniles, decreased food availability, and ultimately reduced numbers of fish (WDOE, 2002).

- pH
  - Most freshwater lakes, streams, and ponds have a natural pH in the range of 6 to 8. Eutrophication, from fertilizers and animal waste affect from improper riparian management affects the chemical composition of the waterbody (University of Minnesota, 2014) and has the potential to affect pH (Allan, 1995). Acid deposition has many harmful ecological effects when the pH of most aquatic systems falls below 6 and especially below 5. As the pH approaches 5, non-desirable species of plankton and mosses may begin to invade. Below a pH of 5, fish populations begin to disappear, the bottom is covered with un-decayed material, and mosses may dominate near shore areas. Below a pH of 4.5, the water is essentially devoid of fish. The most serious chronic effect of increased acidity in surface waters appears to be interference with the fish's reproductive cycle. Calcium levels in the female fish may be lowered to the point where she cannot produce eggs or the eggs fail to pass from the ovaries or if fertilized, the eggs and/or larvae develop abnormally. (Lenntech Water Treatment Solutions, 2013)

- Sedimentation
  - High levels of suspended sediment in the water can affect fish's ability to see and look for food, resulting in a reduction in ability to feed successfully. Also, it can cause coughing, increased respiration, moderate habitat degradation, and impaired homing ability (Berry et al., 2003). Severe impacts of sedimentation include reduced growth and density of fish populations, and increased predation and mortality rates. Fine sediment deposited on the streambed is a major cause of changes in species structure and abundance and may lead to local extinction (Bash et al., 2001).

- Temperature
  - Increased water temperature from reduction in riparian shading adversely affects aquatic organisms and can be lethal (see Section 2.2.e and Table 2-7). In addition, water temperature affects dissolved oxygen levels (see Dissolved Oxygen, above).

- Toxics
  - Not only can toxic pollutants be harmful to fish populations, but also to the local human population who consumes the fish or recreates in the water.

2.3.a.ii. Agricultural Water Quality Management Plan and Best Management Practices

It is possible for landowners to avoid these negative impacts through the employment of best management practices. The Agricultural Water Quality Management Plan guides landowners on how to prevent pollution through these best practices (ODA, 2013). Some basic and common best management practices include but are not limited to:

- Fencing off stream or riverbanks to prevent livestock access.
  - Limiting livestock from unrestricted access to waterways helps prevent bank erosion, sedimentation, and nutrient contamination.
- Planting and protecting riparian vegetation along stream and river banks.
  - Streamside vegetation provides cooling shade for waterways, acts as a filtration device for nutrients and sediments seeping into surface water, and provides fish habitat.
- Pasture management and rotational grazing
  - Rotating livestock regularly to different pastures allows fields a chance to recover from grazing. It gives grass and forage a chance to grow back, stabilizing the soil and thus preventing erosion of topsoil. This practice also promotes a more even distribution of natural fertilizer in the form of livestock feces.

The Agricultural Water Quality Management Act (1993) requires the Oregon Department of Agriculture (ODA) to prevent and control water pollution from agricultural activities. As a result, ODA worked with local advisory committees to develop Water Quality Management Area Plans and Rules through the state. ODA approved the Coos-Coquille Area Plan and Rules in 2002. The Area Plan and Rules apply to all lands in current agricultural use, regardless of size, and those lying idle, or on which management has been deferred. It also applies to agricultural operations within incorporated city boundaries and urban growth boundaries (ODA, 2013).

The Area Plan includes recommended practices that a landowner can choose from. These practices can assist landowners in meeting their business and conservation goals, while also preventing water pollution. The Agricultural Water Quality Management Program focuses on voluntary and cooperative efforts by landowners and others to protect water quality. However, the Agricultural Water Quality Act also provides for enforcement to ensure prevention and control of water pollution from agricultural sources when land managers fail to correct problems. (ODA, 2013)

Agricultural water quality regulations (Area Rules) allow landowners flexibility in how they protect water quality. Area Rules describe characteristics that landowners must achieve on agricultural lands, rather than practices they must implement (ODA, 2013). The local advisory committee helped ODA develop the Area Rules specifically for the Coos-Coquille area. These Rules address water quality objectives identified in the Area Plan. The following is a summary of regulations that apply to the Coos-Coquille area as stated in ODA (2013):

- Application and storage of nutrient inputs to agricultural lands will be done in a manner that minimizes the introduction of nutrients into waterways

- In cranberry production, water storage systems that intercept agricultural drainage containing pesticides and that reapply this water will be designed to minimize percolation of drainage waters. Percolation is the movement of water through soil. Deep percolation is one of the primary transport processes of contaminated water (containing pesticides, nutrients, or other chemicals) back into waterways
- Agricultural activities shall allow the development and protection of riparian vegetation to control water pollution by providing erosion control, sediment and nutrient filtering, moderation of solar heating, and water infiltration into the soil profile
- Application and irrigation systems will be managed to minimize runoff and the introduction of nutrients and farm chemicals into waterways
- Landowner actions may not cause pollution to any waters of the state or place any wastes in a location where such wastes are likely to escape or be carried into the waters of the state by any means

2.3.b. Current Forest Practices

2.3.b.i Private Forest Management and Road Management

Private forest land is managed under the Oregon Forest Practices Act. According to OAR 629-635-0200, streams are classified as Type F (fish and may be used for domestic water), Type D (domestic water with no fish), and Type N (all other streams). Within those classifications they are also classified by size. Small streams have an average annual flow of 2 cfs or any stream with a drainage area less than 200 acres. Medium streams have an average annual flow between 2 and 10 cfs. Large streams have an average annual flow greater than 10 cfs.

Riparian management areas are based on type and size of streams and range between 20 and 100 feet (OAR 629-635-0310). Management within a riparian management area is specified in OAR 629-640. Road construction and maintenance on private forest land also considers stream protection, road drainage, stabilization and wet weather road use as specified in OAR 629-625.

2.3.b.ii Federal Forest Management and Road Management

Current BLM and USFS Land Use Practices

The BLM and USFS National Forest System (NFS) lands within the South Fork Coquille Watershed are currently managed under the Northwest Forest Plan (USDA USFS and USDI BLM, 1994a and USDA USFS and USDI BLM, 1994b). A more specific Coos Bay District Resource Management Plan (RMP) was approved in 1995 (USDI BLM, 1995). The Siskiyou Land and Resource Management Plan (USDA USFS, 1989) was amended by the Northwest Forest Plan.

The Coos Bay RMP “responds to the need for a healthy forest ecosystem with habitat that will contribute toward and support populations of native species, particularly those associated with late-successional and old-growth forests. It also responds to the need for a sustainable supply of timber and other forest products that will help maintain the stability of local and regional economies, and contribute valuable resources to the national economy on a predictable and long-term basis" (USDI BLM, 1995). Lands administered by the federal land management agencies will be managed to maintain healthy, functioning ecosystems from which a sustainable production of natural resources can be provided (USDA USFS, 1989 and USDI BLM, 1995).

The NWFP (USDA USFS and USDI BLM, 1994a and USDA USFS and USDI BLM, 1994b) established the Aquatic Conservation Strategy (ACS), which "was developed to restore and maintain the ecological health of watersheds and their aquatic ecosystems on public lands" (USDA USFS and USDI BLM, 1994a and USDA USFS and USDI BLM, 1994b). Land use practices on National Forest System (NFS) and BLM land must be consistent with the nine objectives contained within the ACS in the short and long terms at the site and watershed scales. A consistency analysis is conducted for actions occurring on NFS and BLM land to ensure the project would not prevent the attainment of the nine ACS objectives. The four components of the Aquatic Conservation Strategy are Riparian Reserves, Key Watersheds, watershed analysis, and watershed restoration. Riparian Reserves are a land use allocation whose width is two site-potential tree heights on fish bearing streams and one site-potential tree height wide on non-fish bearing streams. The RMP describes management direction for actions within the Riparian Reserves. In general, the Riparian Reserves are intended to provide a high level of fish, wildlife and plant habitat, and riparian protection. The NWFP and the Coos Bay RMP established a system of Key Watersheds to serve as refugia for maintaining and recovering habitat for at-risk stocks of anadromous salmonids and resident fish species. There are two types of Key Watersheds – Tier 1 and Tier 2. Tier 1 Key Watersheds contribute directly to conservation of at-risk anadromous salmonids, Bull Trout, and resident fish species. They also have a high potential of being restored as part of a watershed restoration program. The South Fork Coquille Watershed is a Tier 1 Key Watershed (USDI BLM, 1995 and USDA USFS, 1989).

Current BLM and USFS Road Management Practices

Both the BLM and USFS practice road management in conjunction with Best Management Practices in the NWFP (USDA USFS and USDI BLM, 1994a and USDA USFS and USDI BLM, 1994b). The Coos Bay BLM and Siskiyou National Forest RMPs include Best Management Practices (BMPs) that direct the agencies to develop and maintain road transportation systems that serve project needs in an environmentally sound manner. The BMPs are designed to protect water quality, enable the achievement of water quality standards, and maintain soil productivity (USDA USFS, 1989 and USDI BLM, 1995). The BLM also works under the Western Oregon Districts' Transportation Management Plan to manage the transportation system in a manner consistent with the RMP and other current regulations (USDI BLM, 2010). The Rogue River-Siskiyou National Forest roads are governed under the 2005 National Travel Management Rule (USDA USFS, 2005).

The Coos Bay RMP has specific management direction for existing and planned roads in Riparian Reserves with respect to meeting the ACS objectives (USDI BLM, 1995). An analysis is conducted for new road construction to ensure the project would be consistent with the ACS and would not prevent the attainment of the nine ACS objectives.

Within Key Watersheds the BLM RMP (USDI BLM, 1995) states there can be no net increase in road mileage unless the BLM has made efforts to reduce existing road mileage. The Transportation Management Plan states "only the full decommission and obliteration categories are appropriate to meet the management Direction of a reduction or no net increase in the amount of roads within Key Watersheds" (USDI BLM, 2010).

2.3.c. Gravel Extraction (Mining)

Sediment production is naturally high in the South Fork Coquille Watershed (USDI BLM, 1996; USDA USFS, 2007; and Jones et al., 2012). The Klamath Mountains geologic province overlays a substantial portion of the watershed, with the metamorphosed sedimentary rock formations of the province providing a source of sand and competent gravel. Documented mass wasting events include a large landslide in Salmon Creek that occurred after an extreme rain-on-snow flood in 1890 (USDI BLM 1996).

The movement of sediment interacts with channel morphology in the lower South Fork Coquille River, where the reaches are either supply limited or capacity limited (Jones et al., 2012). (Also refer to the South Fork Coquille Change Detection: Channel Centerline, Width and Bar Measurements Section 4.4.)

The Myrtle Point reach (RM 0-4.8) is capacity limited, meaning that there is more sediment entering the reach than can be transported out. This is due to the very low gradient in this reach, increased channel width, and effects of tide cycles. The capacity limitation led to dredging this reach in the late 19th and early 20th centuries. A USGS study (Jones et al., 2012) noted that bar area, total number of bars and unit bar area were increasing to 2009, which suggests deposition. However, updated analysis of bar characteristics in this reach from 2009-2011 found decreasing bar area and number of bars that changed the long-term averages (1939-2009) to a trend of bar maintenance rather than bar building (Inter-Fluve, Inc. 2013). Further, areas of widening and incision in the Myrtle Point reach suggest that there may be a net loss of sediment from the reach. Since this reach is at the base of the watershed, it is more susceptible to disturbance and changes in the supply of sediment. The Broadbent reach (RM 4.8-23.5) is another capacity limited reach, which is an almost continuous low gradient, alluvial channel with high unit bar area. The historical trend (1939-2009) is for overall decreases in bar area and the total number of bars, as well as channel widening and incision. However, similar to the Myrtle Point reach there has been an accelerated shift of sediment removal, observed in monitoring data from 2009-2011, when compared with the 1939-2009 period. These trends suggest net removal of sediment from the reach (Inter-Fluve, Inc. 2013).

The Powers reach (RM 23.5-35.1) is supply limited; meaning that the river can transport more sediment to downstream reaches than is delivered to it. The causative factors include the relatively higher gradient and more resistive bed and banks, leading to channel confinement. Specific gage analysis at the USGS gage near Powers found consistent thalweg lowering at the gage, caused by channel incision (Inter-Fluve, Inc. 2013). Further, bar area and number of bars are decreasing in the long-term. These results support a case for sediment supply limitation.

Despite incision and depletion of bar features, it is likely that the Powers reach is somewhat more resilient to changes in sediment supply than reaches downstream (Inter-Fluve, Inc. 2013).

Gravel has been extracted (mined) from bars along the South Fork Coquille River to make concrete and support construction needs since the 1920s (Jones et al., 2012). The Oregon Department of Geology and Mineral Industries (DOGAMI) indicate the approximate locations of 54 mines for sand and gravel along the channels and floodplains of the mainstem, forks, and tributaries of the Coquille River (Oregon DOGAMI, 1999).

Consistent records are not available to develop a complete historical record of gravel mining, excepting 1974-1978 and more recently from 1996 to 2009. From 1974 to 1978, a total gravel volume of at least 306,600 m^3 was mined from multiple sites on Salmon Creek, the South and Middle Forks, and mainstem of the Coquille River. For this period, total reported annual volume mined in all of these sites combined ranged from at least 58,700 to 68,300 m^3.

As shown in Table 2-18, gravel mining on the South Fork Coquille has been concentrated since 1996 in the Broadbent reach (RM 4.8-23.5) of the South Fork Coquille River at the Lokan, Herman, Broadbent, Coos Highway, Thompson, and Hayes Bars (Jones et al., 2012).

Table 2-18 indicates annual deposition volumes at mined bars averaged over 34,700 m^3 from 1996 to 2009, suggesting that the annual bed-material transport in the South Fork Coquille River at least exceeded this value. From 1996 to 2009, the reported cumulative volume of gravel mined from the Broadbent reach of the South Fork Coquille River was at least 207,100 m^3, or approximately 43 percent of the reported volume of deposited sediment (Jones et al., 2012).

Sediment deposition is highly correlated with bankfull or larger floods. From available data, cumulative deposition volumes were greatest following the 2-year recurrence-interval flood on December 2, 1998 and 50-year recurrence-interval flood on November 18, 1996. For individual sites with multiple deposition estimates, annual deposition volumes varied between sites and years (Jones et al., 2012).

As of 2011, six instream mining permits with a cumulative annual removal limit of approximately 76,400 m^3 from multiple sites on the South Fork Coquille River are on file with the Corps of Engineers and Oregon Department of State Lands (Jones et al., 2012). It is not known whether each permit is fully utilized on an annual basis. However, the total permitted volume appears to exceed the mean recruitment volume estimate of 34,700 m^3 calculated between 1996 and 2009.

Estimating the effects of gravel extraction (mining) varies by: increasing streamflow levels where higher water velocities can mobilize significant volumes of sediments, channel morphology, and individual reach specific hydraulic properties. Gravel extraction in a supply limited reach may increase bed and bank scour causing down-cutting but not necessarily widening. Gravel extraction in a capacity limited reach may decrease bar area or numbers of bars or cause bar armoring with larger substrate. Gravel extraction in a capacity limited reach can also lead to less channel meandering (reduced sinuosity), increased stream slope, possible multiple thread channels, and channel widening. Detailed studies along the South Fork Coquille

River near gravel extraction sites and reference sites would enable more quantitative assessments of changes in bar replenishment and morphology in relation to gravel extraction on bed-material flux and peak flows (Jones et al., 2012). Further, the effects of downstream channel conditions and changes should be studied.

Table 2- 18. Annual summary of reported volumes of deposited and mined gravel from 1996 to 2009 for instream mining sites in the Broadbent reach of the South Fork Coquille River (Jones et al., 2012).

Reported Cumulative Volumes (m^3)			
Year	**Deposited**	**Mined**	**Notes**
1996	28,700	--	Only mining inactivity at Thompson Bar reported
1997	67,800	7,000	
1998	56,200	17,600	
1999	69,000	55,100	
2000	39,300	20,600	
2001	13,700	700	
2002	29,800	28,800	
2003	32,400	22,100	
2004	37,100	0	Mining inactivity reported for all sites except for Coos County Hwy Bar
2005	21,500	19,500	
2006	28,100	22,300	
2007	--	--	Only mining inactivity at Thompson Bar reported
2008	26,300	--	Only mining inactivity at Thompson Bar reported
2009	35,700	13,400	
Mean Volume	34,700	14,800	
Cumulative Volume	485,600	207,100	

2.3.d. Water Availability and Withdrawal

South Fork Coquille River Water Availability (from OWRD 2002)

Oregon Water Resource Department (OWRD) has created and maintains a database of the amount of surface water available for appropriation for most waters in the state. By examining water availability we are able to understand the influences that water *quantity* may have on water *quality*. Water availability is obtained from natural stream flow by subtracting existing storage, out-of-stream consumptive uses and instream demands. Water availability has been calculated for over 2500 Water Availability Basins (WAB). In general, the calculation of water availability at one WAB cannot be considered in isolation from other WABs in the same stream system.

Stream flow can be highly variable, and it is useful to characterize it in some way, usually by a statistic, e.g., a monthly or annual mean. The appropriate statistic in this case is exceedance stream flow. This statistic gives us the probability of a given rate of stream flow to occur based upon historic flow records or estimated through modeling.

Consumptive use from allocations for out-of-stream uses can total no more than the 80-percent exceedance natural stream flow, and allocations for instream flows can be no more than the 50-percent exceedance natural stream flow. When consumptive use flow allocations meet these thresholds water becomes unavailable for additional consumptive uses both upstream and downstream. Consumptive use is divided into three major categories: irrigation, municipal, and all others e.g., domestic, livestock.

Consumptive uses of water in the South Fork Coquille River are shown in Figure 2-17. The majority of the consumptive use is for irrigation followed by domestic uses (Figure 2-17). Allocations for the South Fork Coquille River vary by month (Figure 2-18). During periods where values fall below zero, no water is available for allocation and junior (or later) water rights may be shut off. Negative values illustrate that stream flows are over allocated and activities that augment instream flows would be beneficial to allow for instream flows as well as most users to obtain water.

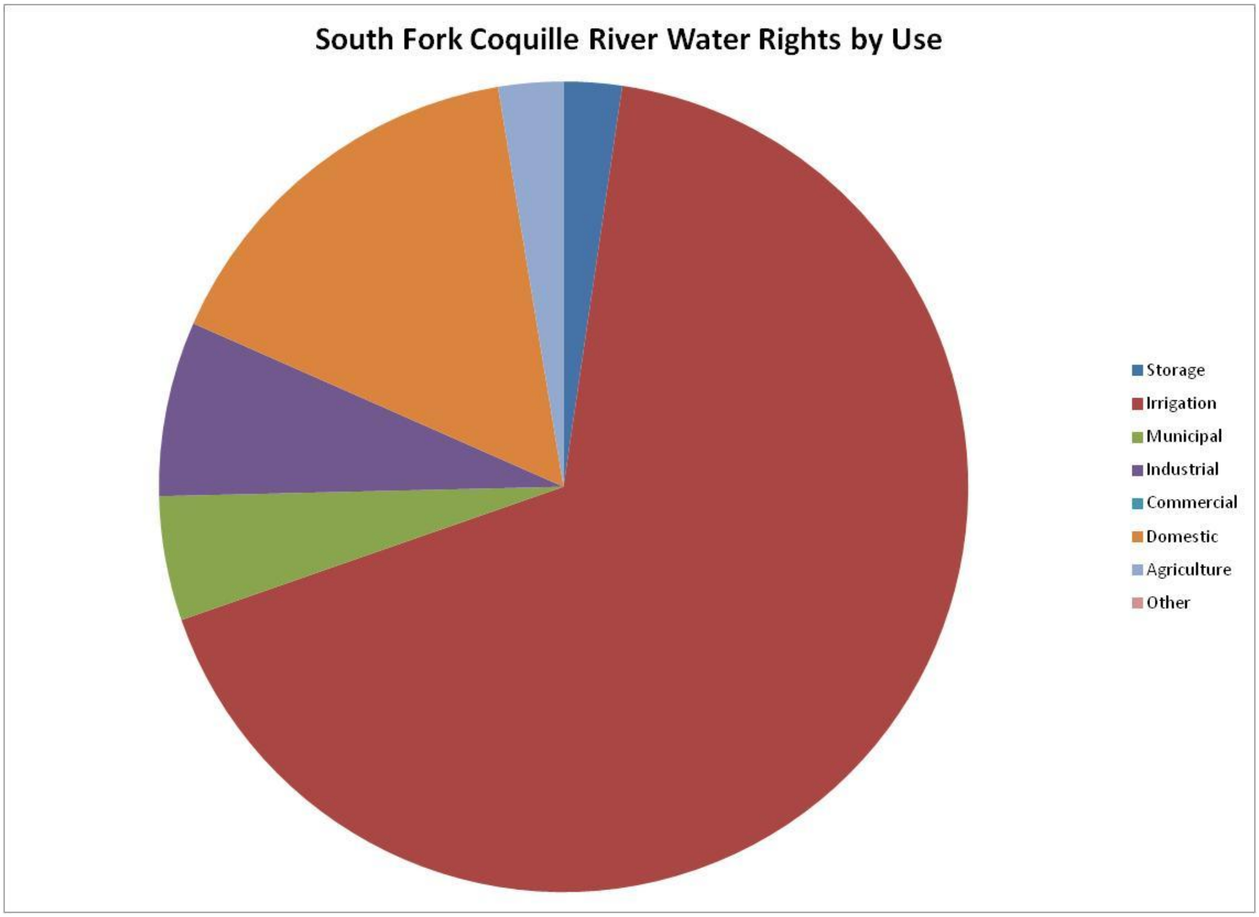


Figure 2- 17. South Fork Coquille River water rights by consumptive use (OWRD, 2014).

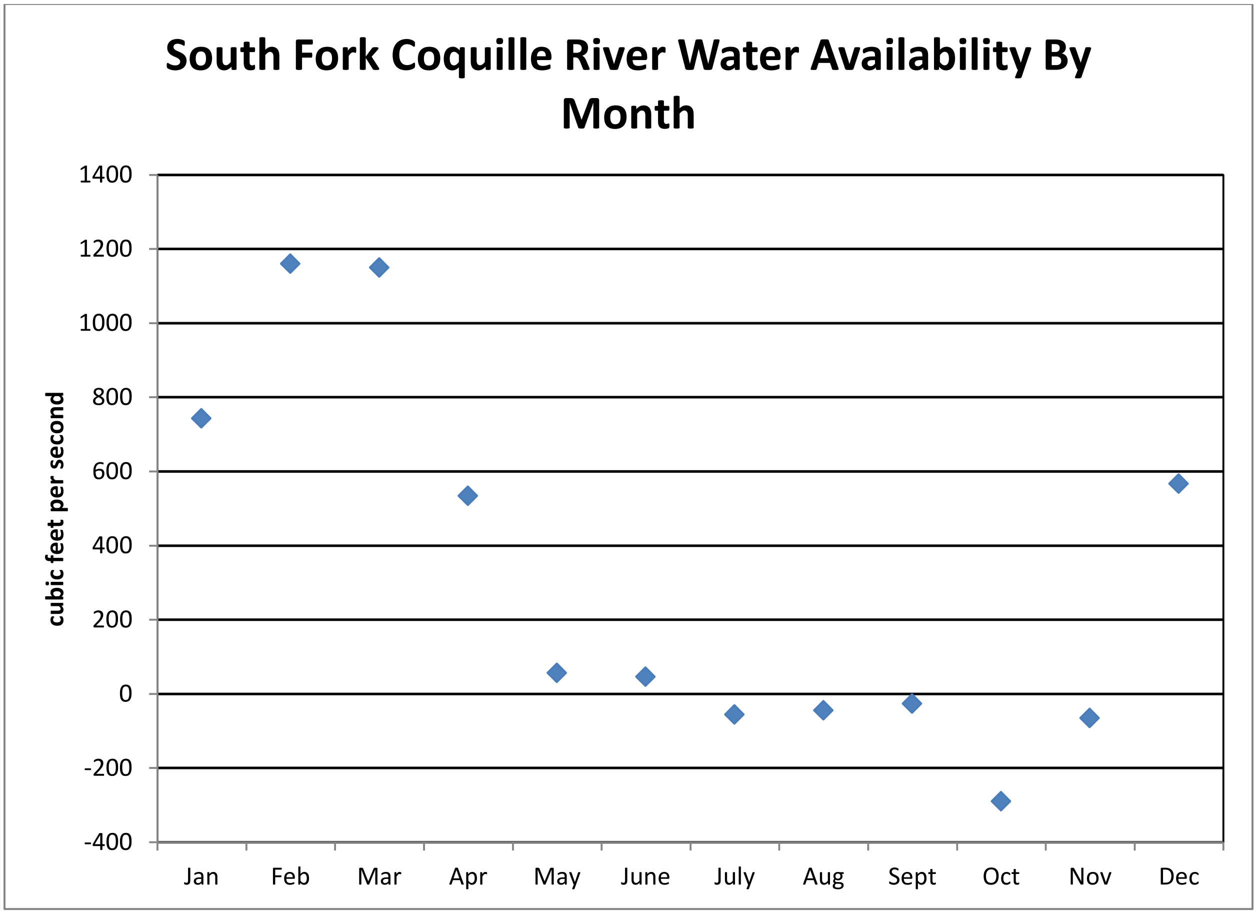


Figure 2- 18. South Fork Coquille River water right availability by month (OWRD, 2014).

Instream Water Rights

Instream water rights are water rights that leave water in streams and lakes for beneficial public uses such as recreation, pollution abatement, navigation, maintenance, and enhancement of fish and wildlife populations and their habitats (ODFW, 1997). The OWRD holds these instream water rights in trust. There are two types of instream demands: instream water rights and scenic waterway flows. Instream demands diminish availability upstream only (ODFW, 1997). Because they are non-consumptive, they do not diminish stream flow downstream as do consumptive uses.

The ODFW developed instream flows by month needed to support anadromous salmonid species and used this information to set minimum perennial stream flows throughout Oregon. These instream water rights are enforced like all other water rights. A water right priority date establishes the order of water use and a junior water right cannot take away or impair any legally established water use having an earlier priority date. (ODFW, 1997)

Many of the instream water rights established to protect fish and wildlife populations are junior to other existing water rights and there is little assurance of instream flow protection, particularly in dry years. Various conservation measures are being implemented to help augment instream flows including measurement, efficiency, lease, and acquisition programs. (ODFW, 1997)

Water Withdrawal for Irrigation

Today, irrigation alone accounts for 82% of total surface water withdrawals in Oregon (Joyce, 2002). When large amounts of water are pumped or otherwise withdrawn from a stream for irrigation purposes, there is less water instream. This results in shallower rivers and streams. The increased surface area to volume ratio in these shallow waterways results in increased stream temperatures. When riparian vegetation is limited, water temperature in these shallow systems will increase even more.

Irrigation Best Management Practices

Major objectives for good irrigation management practices include knowing the precise amount of water to apply for the soil type in order to minimize surface runoff and deep percolation. These two processes are the primary transport mechanisms causing water contamination. Through these processes, sediments, chemicals, and fertilizers can be transported into waterways, negatively impacting anadromous and resident fish populations and overall water quality. The Agricultural Water Quality Management Plan encourages landowners to understand their soil's infiltration rate and to apply water according to soil moisture in the root zone. (Joyce, 2002)

The following best management practices are from Joyce (2002)

- Analyzing soil and knowing crop needs to prevent over-application
- Consulting local resources such as Soil and Water Conservation Districts, the Natural Resource Conservation Service, Oregon State University (OSU) Cooperative Extension service, and consultants to develop an irrigation water management plan
- Maintaining ditches, tide gates and pipelines to minimize water losses
- Maximizing water system efficiency by checking field layouts to ensure correct combinations of spacing, operating pressure, sprinkler head, and nozzle size/type that match the soil infiltration rate
- Leasing water rights to instream use during periods of non-agricultural use
- Providing fish screening at irrigation intakes (unscreened irrigation intakes suck in fish as well as unwanted debris. State law requires irrigators to screen diversions that divert more than 30 cubic feet per second)).
- Checking field layouts for flow uniformity.
- Maintaining good soil fertility to make effective use of irrigation water

Flow Restoration Priorities

The OWRD and the ODFW jointly identified priority areas for stream flow restoration in basins throughout the state. These priority areas represent watersheds in which there is a combination of need and opportunity for flow restoration to support Oregon Plan for Salmon and Watersheds fish recovery efforts. ODFW developed and implemented a process to identify the watersheds in which fish were more likely to respond to increased flows and the OWRD identified those watersheds in which there are the best opportunities to restore flows. This prioritization process yielded a value reflecting the need for flow restoration during each season in each water availability basin (WAB). A WAB is the watershed unit used for OWRD water availability calculations. There are more than 2,500 water availability basins in the state. These values were divided into the following four classes: Low, Moderate, High and Highest. (ODFW and OWRD, 2002)

Table 2- 19. South Fork Coquille River flow restoration needs (ODFW and OWRD, 1998).

Water Availability Basin	Need	Opportunity
16110 South Fork Coquille River @ Mouth	Highest	Fair
161111 Ward Creek @ Mouth	High	Poor
16111 Catching Creek @ Mouth	High	Poor
161140 Dement Creek @ Mouth	Moderate	Poor
161130 Rhoda Creek	Moderate	Poor
161150 Yellow Creek	Moderate	Poor
161160 Beaver Creek @ Mouth	Moderate	Poor
161180 Woodward Creek	Moderate	Poor
161191 Salmon Creek @ Mouth	Moderate	Poor

Flow restoration priorities for the South Fork Coquille River are summarized in Table 2-19 and can be viewed in further detail at ODFW and OWRD (1998). The WAB identified as South Fork Coquille River @ mouth is identified among the highest statewide priorities for flow restoration (Table 2-19). Other WABs in the South Fork were identified as having a high need for flow restoration but were not prioritized as yet (Table 2-19).

2.3.e. Riparian Vegetation – Focusing on River Corridor

Current Condition of Riparian Vegetation related to Historical Uses

In 1995, a report authored by Florsheim and Williams evaluated the geomorphic processes in the South Fork Coquille Watershed, and outlined design recommendations to address erosion problems. Florsheim and Williams (1995) covered only the portion of the lower South Fork Coquille River equivalent to Reach 2 in this report (See Table 1-3) from approximately RM 5 to 10.

According to Florsheim and Williams (1995), loss of the riparian vegetation buffer occurred due to grazing and agricultural clearing of the flood plain to the edge of the channel. This left a narrow strip of vegetation or no vegetation along the river. Riparian vegetation along riverbanks stabilizes the bank and prevents erosion, when the vegetation is removed, the rate of erosion increases dramatically. In addition, after land clearing for agricultural purposes there was a reduction in large wood available to fall into the stream channels, since there were no longer sources of wood (Benner, 1991). Currently, cattle graze the floodplain and make trails to the river to drink water further damaging riparian vegetation (Florsheim and Williams, 1995).

Historic aerial photographs from 1939, 1943, 1967, 1977, 1980, 1981, 1986, and 1992 show a narrow strip of riparian vegetation along the meandering channel. Figure 2-19 compares the channel boundary in 1939 to 1992 and shows locations of bank erosion and meander migration. The area lost to bank erosion between 1939 and 1992 is about 10 acres or only 0.2 acre/year in the five study reach. This bank erosion is episodic, and tends to be localized near the outside of bends or where riparian vegetation has been removed. Bank erosion has caused loss of valuable agricultural property, riparian vegetation and habitat, threatens roads, and contributes fine sediment to the channel. The fine silt and clay has deleterious effects on aquatic habitat by filling pools and reducing water quality. Field reconnaissance (in 1995) suggests that channel bars are currently in the same location as in 1992, however, local bank erosion and channel widening indicates the dynamic nature of river processes (Florsheim and Williams, 1995)

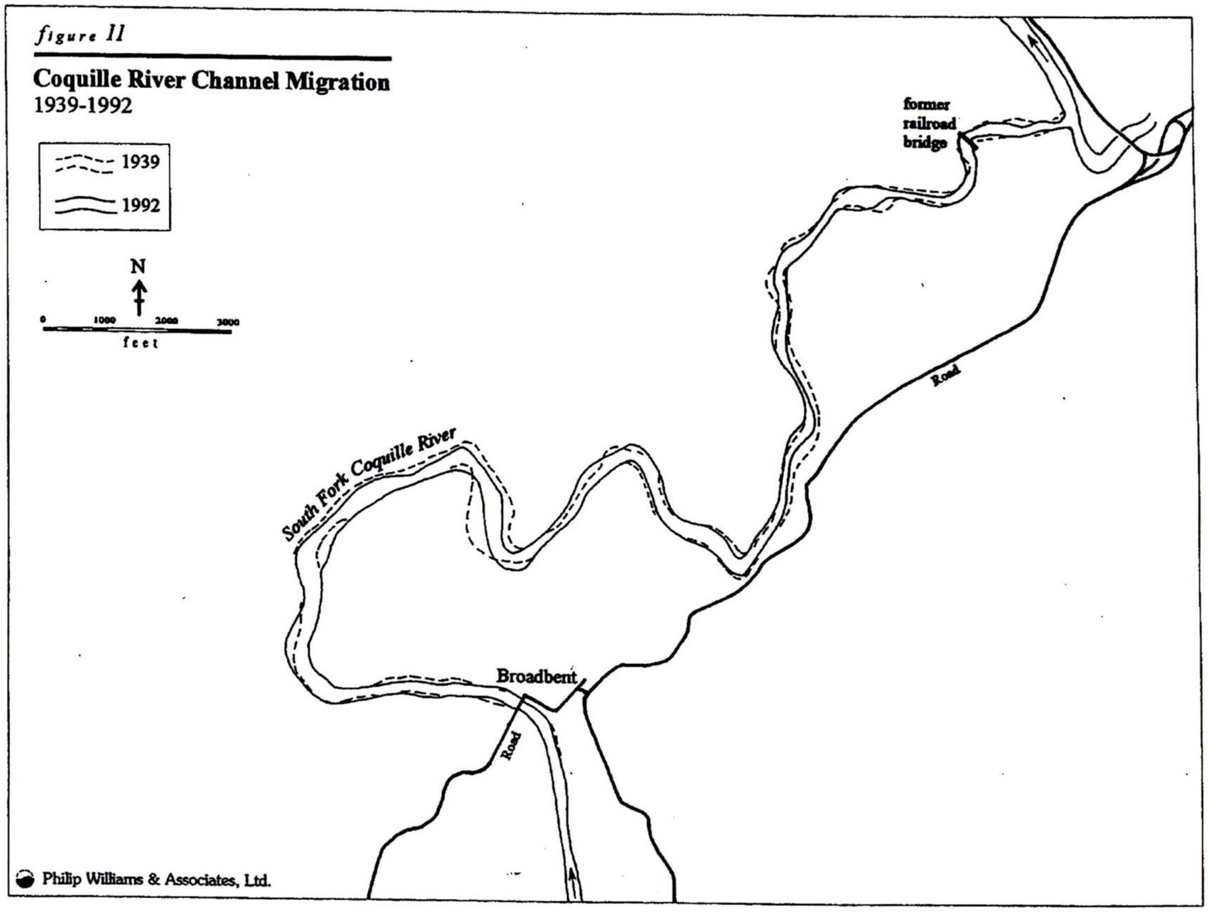


Figure 2- 19, Comparison of 1939 channel to 1992 channel (Florsheim and Williams, 1995).

In 2003, Clearwater BioStudies, Inc. prepared a report for the Coquille Watershed Association, which included a report and field assessments of 34.7 miles of the South Fork Coquille River from the mouth to the boundary of the Siskiyou National Forest, including three tributaries: Dement Creek, Yellow Creek, and Hayes Creek (Figure 1-3). Clearwater BioStudies, Inc. (2003) Reaches SFC 1-8 are roughly equivalent but not identical to the reaches designated in this Action Plan (Table 1-3). Clearwater BioStudies, Inc. (2003) incorporated much of the historic data from Florsheim and Williams (1995), as well as updated information following the major flooding of 1996.

Clearwater BioStudies, Inc. (2003) compared 1939 and 1997 air photos for a portion of the lower South Fork Coquille River. The following general changes were noted: first, most of the historic loss of riparian forests that Benner (1991) described for the lower South Fork Coquille River occurred prior to 1939; and second, gravel deposition was more extensive along most of the lower South Fork Coquille in the earlier (1939) photos than in the more recent (1997) ones, suggesting major inputs of sediment to the channel when the watershed was first settled. (Clearwater BioStudies Inc., 2003)

Significant areas of eroding, raw, or poorly vegetated banks were found but riverbanks that support woody riparian vegetation and that do not appear to be eroding to an appreciable degree are more abundant along the South Fork Coquille than are eroding banks, even in the river reaches exhibiting the greatest levels of bank instability (Clearwater BioStudies, Inc., 2003).

Riparian vegetation along the South Fork Coquille River varied from dense stands of deciduous trees with a brush/grass understory to areas supporting only grazed grasses with scattered brush. The three river reaches with the least vigorous and most shallow-rooted streamside vegetation, had the widest and least stable channels (Clearwater BioStudies, Inc., 2003). Riparian vegetation was mapped along the mainstem to estimate the percentages of total riverbank length supporting grass/forb, shrubs, sparse trees, and dense trees (Figure 2-20 and Table 2-20). The photo overlays, which could be used to help select areas for riparian restoration projects, are on file with the CWA.

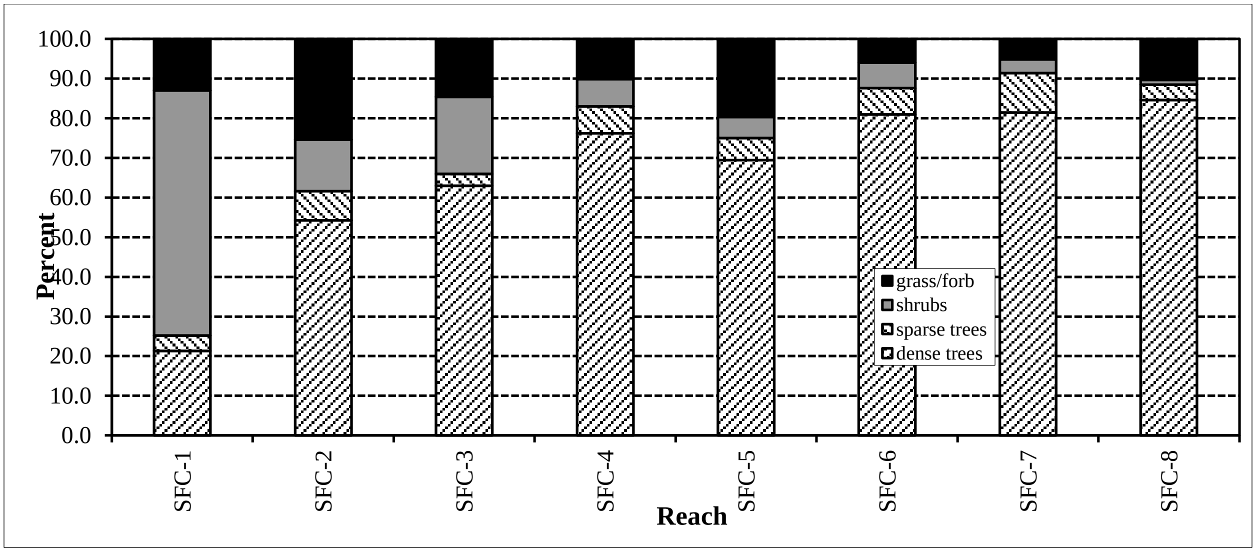


Figure 2- 20. South Fork Coquille (SFC) River riparian class composition in 2001 (Appendix H in Clearwater BioStudies, Inc., 2003).

Table 2- 20. South Fork Coquille (SFC) River riparian class composition percentages in 2001 (Appendix H in Clearwater BioStudies, Inc., 2003).

Reach	dense trees	sparse trees	shrubs	grass/forb
SFC-1	21.3	3.9	61.8	12.9
SFC-2	54.3	7.3	13.0	25.4
SFC-3	63.0	3.0	19.4	14.6
SFC-4	76.2	6.8	6.9	10.1
SFC-5	69.4	5.6	5.3	19.7
SFC-6	81.0	6.6	6.5	5.9
SFC-7	81.5	9.9	3.5	5.1
SFC-8	84.6	3.9	1.2	10.3

Photo-based analysis performed by Clearwater BioStudies (2003) (See Appendix C) of the relative condition of riparian vegetation bordering the lower South Fork suggests several patterns (Table 2-21). Dense stands of riparian trees were present along most of the South Fork Coquille River's banks within all but the lower-most study reach (SFC-1), where shrub communities predominated. (See Table 1-3 for a crosswalk of reach names with reach names used in this document.) Riverbanks supporting shrub or grass/forb communities with very few or no trees accounted for less than a quarter of the banks within reaches above Dement (SFC4 through SFC-8) but greater and increasing proportions of the banks as the river passed from Dement to the mouth (from SFC-3 to SFC-1). Banks supporting only grass/forb communities, a clear reflection of recent disturbance, were present within each of the study reaches but were most common in reach SFC-2, where channel instability and at-risk banks were most prevalent (Clearwater BioStudies, Inc., 2003).

Table 2- 21. Riparian changes between 1939 and 1997 (Figure C-1 in Appendix C of Clearwater BioStudies, Inc., 2003).

Reach Clearwater BioStudies, Inc. (2013) (CBS) Reach River Mile	Location	Riparian changes from 1939 to 1997 noted by Clearwater BioStudies, Inc. (2003) and Florsheim and Williams (1995).
Reach 1 CBS Reach SFC-1 River Mile 0-4.73	Mouth to Middle Fork Coquille River	Riparian canopy tended to get narrower. Wider channel openings suggest that channel width increased or large trees overhanging channel were lost, or both.
Reach 1 & 2 (portions) CBS Reach SFC-2 River Mile 4.73-9.45	Middle Fork Coquille River to Broadbent	Riparian canopy width changed little. Average channel width increased substantially after 1992. All riparian trees lost on multiple sample points, which "appears to reflect very recent morphological changes within the reach".
Reach 2 & 3 (portions) CBS Reach SFC-3 River Mile 9.45-15.14	Broadbent to Dement Creek	Change varied but tended toward narrower channel openings and wider riparian canopy widths. Multiple sample points had riparian canopies considerably wider in 1997 than any of the sample points had in 1939.
Reach 3 & 4 (Portions) CBS Reach SFC-4 River Mile 15.4-18.8	Dement Creek to Gaylord	Significant reduction in the mean riparian width. Multiple sample points lost all riparian trees.
Reach 4 & 5 (Portions) Reach SFC-5 River Mile 18.8-23	Gaylord to Rowland Creek	Riparian corridor width declined significantly; trees removed from the outer portion of wide stands of trees by land clearing. Wide channel openings were reduced with strong channel narrowing and riparian encroachment.

The Role of Vegetation in Promoting Bank Stability

Historically, there was the perception that vegetation should be eliminated because of its roughness slowing down the water (Florsheim and Williams, 1995). However, in contemporary times, the view of the role of riparian vegetation has changed and it is seen as having a role in stable channel design, a geomorphic approach. The geomorphic approach toward stable channel design recognizes the beneficial effect of vegetation on bank stabilization and habitat values, and accommodates these factors within the criteria for channel design (Florsheim and Williams, 1995).

The presence of riparian vegetation helps stabilize channel banks because root systems of trees and shrubs increase strength of the bank material and provides resistance to bank erosion. Removal of riparian vegetation due to human activity or floods makes the channel banks more vulnerable to erosion. Riparian vegetation on channel banks increases channel roughness and the resistance to flow and decreases flow velocities. A decrease in velocity raises the flood inundation level, reduces the flow shear stress and creates the conditions for increased sediment deposition. Brushy riparian vegetation on banks may trap fine grained sediment in suspension or organic material in transport and store it on the banks. (Florsheim and Williams, 1995)

Other areas of concern related to bank stability issues reported in Clearwater BioStudies, Inc. (2003) included:

- Although eroding banks were distributed throughout the lower river, their frequency, severity, or both, were greatest in reaches below Gaylord … and particularly in the reaches below Dement.
- Areas of the South Fork Coquille River below Dement that experienced the most severe bank erosion during recent floods no longer have a natural buffer of woody riparian vegetation to protect deep valley soils against removal by the river during floods.
- In addition to poor riparian conditions, some of the most severely unstable channel segments below Dement appear to have been influenced by changes in the river's alignment or behavior following placement or repositioning of rock bank protection structures.
- The severity of recent bank erosion at multiple locations along the lower river, where some raw banks were 25-30 feet tall in 2001, suggests that the causes are likely systemic … as well as local.
- Dense patches of Scouler's willow (*Salix scouleriana*) were growing in lower to mid-bank positions at a substantial proportion of stable sites along the South Fork below Dement, suggesting that there may be an important role for this or other willow species in maintaining or restoring channel stability in the area.
- Livestock have been fenced back from the South Fork Coquille River in many areas, but they continue to damage riparian vegetation and streambanks along portions of the lower river, including at least two sites where the CWA has sponsored bank stabilization projects.

2.3.f. Coquille Valley Wildlife Area (Winter Lake and Beaver Slough)

Historically, the Coquille River utilized its entire floodplain, through braided channels that included those that now occur on pasture land behind dikes. This floodplain was dominated by woody, wetland-tolerant species (Benner, 1991). Coho Salmon and migratory waterfowl (as well as other fish and wildlife species) made use of areas. When high water conditions occur, substantial portions of South Fork Coquille River are turbid and the currents are strong. Juvenile fish seek areas off-channel (such as historic wetlands) where there is cover, less turbidity, and weaker current. Waterfowl seek newly flooded areas for new feeding opportunities in relatively shallow water (less than 18 inches in depth) throughout the Coquille Valley that were seasonally inundated. It is estimated that over 95% of historic wetlands have been lost in the Coquille Valley (Benner, 1991). These complex winter and spring habitats offered slow-water refugia (food, cover, protection from predators) for Coho Salmon that allowed additional growth and accumulated energy reserves that translated directly into better survival.

In 2013, Oregon Department of Fish and Wildlife (ODFW) completed a land exchange of timbered property near Eel Lake (north of Lakeside, Oregon) for approximately 546 acres of historic wetland habitat in the Coquille Valley in an area known as Winter Lake and Beaver Slough (Figure 2-21). In the land exchange, ODFW acquired two parcels separated by privately held agricultural property. To the north, the Beaver Slough Tract has retained most of its native vegetation components (flooded wetland forest dominated by willow and ash), while the Winter Lake Tract has been altered for agriculture through dike building, channelization, vegetation removal and hydrologic isolation through the use of tidegates. Tidegates have been historically designed to allow one way movement of water. An incoming tide or high water forces the door shut from the outside. When the pressure on the door is greater on the inside, the door is forced open and water is released. The older style tidegates used throughout the Coquille Valley did not allow free movement of water in both directions; hence, they have hydrologically isolated large areas adjacent to the mainstem Coquille River.

ODFW has partnered with The Nature Conservancy (TNC) to restore a portion of the historic ecosystem functions that once supported greater populations of fish and wildlife. The partners are working to design and build a meandering stream channel on the property; plant the property with a mix of endemic wetland vegetation; develop topographic variations that mimic natural wetland processes; and place large wood that will add to stream channel complexity. Additionally, the China Creek Gun Club, an adjacent property owner, is allowing development of a meandering stream channel through their property and to a new tidegate structure. This will offer additional high quality rearing habitat for juvenile salmon, as well as benefits to wildlife such as dabbling ducks and amphibians. Concurrently but separately, the Beaver Slough Drainage District (BSDD) is working to replace the failing tidegate and berm infrastructure that provides water management for working farms, and will isolate the ODFW property from the Coquille River with a new design that will allow tidal activity onto the ODFW property. Hydrologic connectivity will offer numerous benefits, including: better access to off-channel habitat by native migratory fish and wildlife; improved water quality and associated productivity (plants, insects); and an anticipated decline in exotic fish species such as Brown bullhead and Yellow perch.

Juvenile fish from the South Fork Coquille Watershed use Winter Lake and Beaver Slough during certain life stages. Over-wintering habitat has been determined as a limiting factor throughout the watershed. For fish resources, these areas (and other off-channel areas) may be used for several weeks by juvenile fish during out-migration. These highly productive areas translate to a larger size when fish move to the ocean, which translates to greater survival and more returning adults.

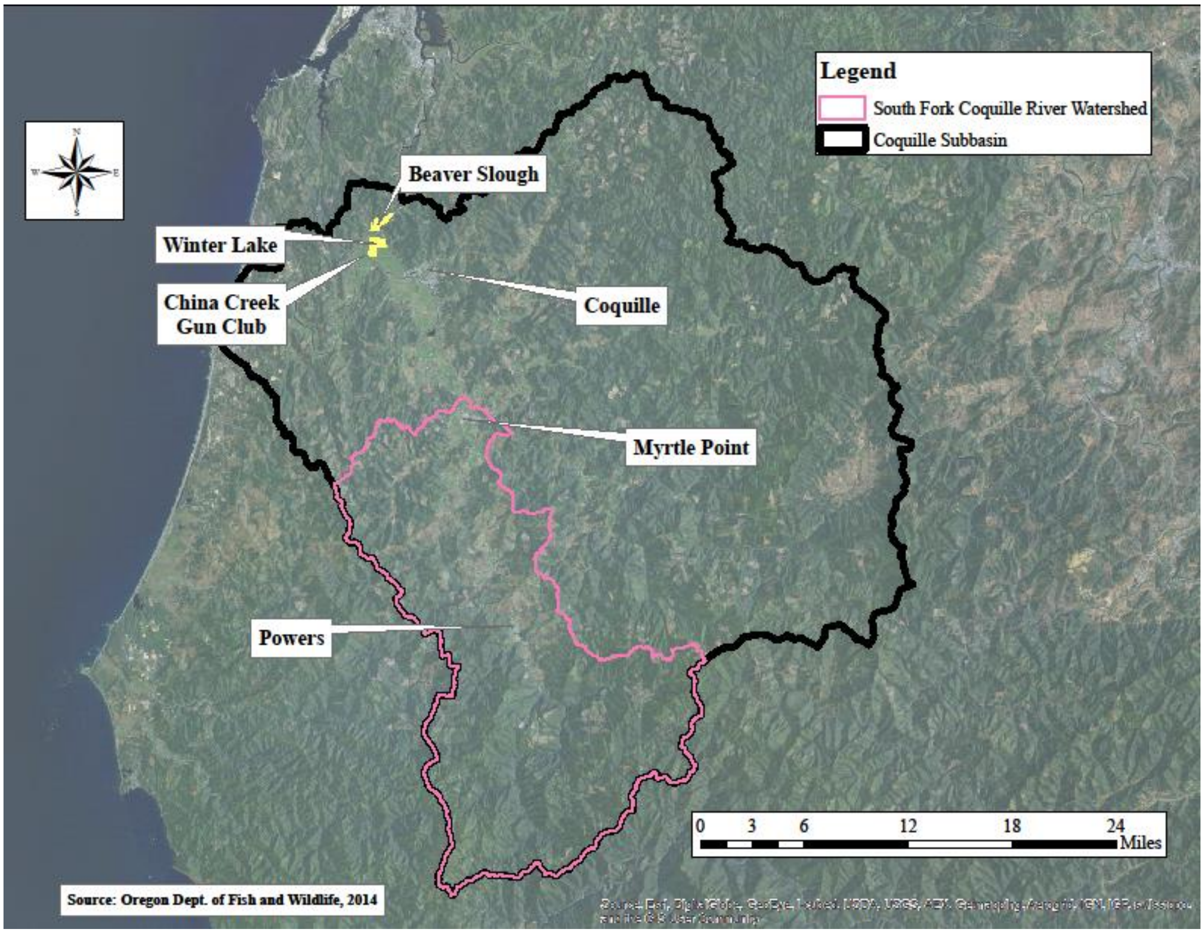


Figure 2- 21. Map of Winter Lake and Beaver Slough.

Chapter 3: Past Restoration Efforts

3.1. Restoration Need

Beginning in the late 1800s, instream obstructions such as snags and log jams and riparian vegetation were removed to facilitate log drives on the South Fork Coquille River (See Section 2.1 for more information). Not too long afterwards, the effects of bank vegetation removal were recognized by the U.S. Army Corps of Engineers (Benner, 1991). In its Annual Report of 1891-92, it was noted that river banks left untouched showed little change while streambanks cleared of riparian vegetation were unstable and prone to erosion (Benner, 1991). There was a large flood in 1890 and the instream and riparian disturbance had altered conditions resulting in this erosion (Benner, 1991). Even though the linkage between streambank vegetation and bank stability was known, vegetation continued to be removed throughout the South Fork Coquille Watershed throughout the 1900s. In addition, aquatic habitat was greatly impacted by these anthropogenic activities. River sediments that would have been held up have been transported downriver, more sediment is mobilized at a wider range of hydrologic events, which smothers fish eggs in the gravel and has numerous physiological effects on juvenile fish. Additionally instream structure is used by juvenile fish cover during high flows and provides feeding opportunities year-round. Instream and riparian vegetation also acts to sort sediments, providing adults with high quality spawning habitat. (See Section 2.1 and 2.3 for more information.)

A variety of techniques were used to curb streambank erosion issues, including the use of deflective structures, pilings, boulders and car bodies. While hard materials such as boulders can solve site-specific bank erosion issues, often they cause unintended erosion problems downstream by deflecting force onto an unprotected bank, delivering more pressure than a section of bank may be able to handle, therefore, continuing the erosion problems downstream. Today, bioengineering is incorporated into streambank restoration which relies not only on hard materials such as boulders, but also incorporates natural materials such as wood and live plantings.

3.2. Restoration Effort Summary

3.2.a. South Fork Coquille Watershed Restoration Since 1995

While there are many effective projects on both the mainstem and in tributaries that took place prior to 1995, beginning in 1995, the Oregon Watershed Restoration Inventory (OWRI) began cataloging projects in a database that is accessible to many agencies and user groups. The OWRI database includes project descriptions, locations, objectives, method used, area impacted and improved (miles, acres, or number of road improvement structures). This data is summarized in Table D-1 of Appendix D. To improve the ease of use of the table, the corresponding Inter-Fluve, Inc. (2013) reach number was included (see Table 1-1 for a crosswalk of these reaches). Unfortunately, the records prior to 1995 are not as complete and in order to not unintentionally exclude restoration projects, they are not included in Table D-1 of Appendix D. General locations of restoration project, along with type of project, are also mapped in Figure 3-1. While effort was made to include all projects from 1995-2013, but it is possible that other projects were completed that are not included in this table.

Also, there are projects reported to OWRI, particularly during the 1990s that today may not be considered restoration by today's standards, such as riparian tree removal. More recently, the value of intact riparian areas and their value to ecological function and watershed processes has become better recognized. Many road improvements are being completed in the watershed each year that positively affect stream condition; however, those records are maintained in a different manner and weren't compatible with the OWRI data so weren't included in Table D-1 of Appendix D (See Section 2.3.b. for more information on road restoration and maintenance of forest land). The USFS wrote an Aquatic Restoration Plan for the South Fork Coquille Watershed (USDA, 2007). They have used this to focus their restoration efforts in the watershed and in 2012, produced a document, the Watershed Restoration Accomplishment Brief (USDA, 2012) which summarized restoration accomplishments in the headwaters South Fork Coquille River Priority Subwatershed.

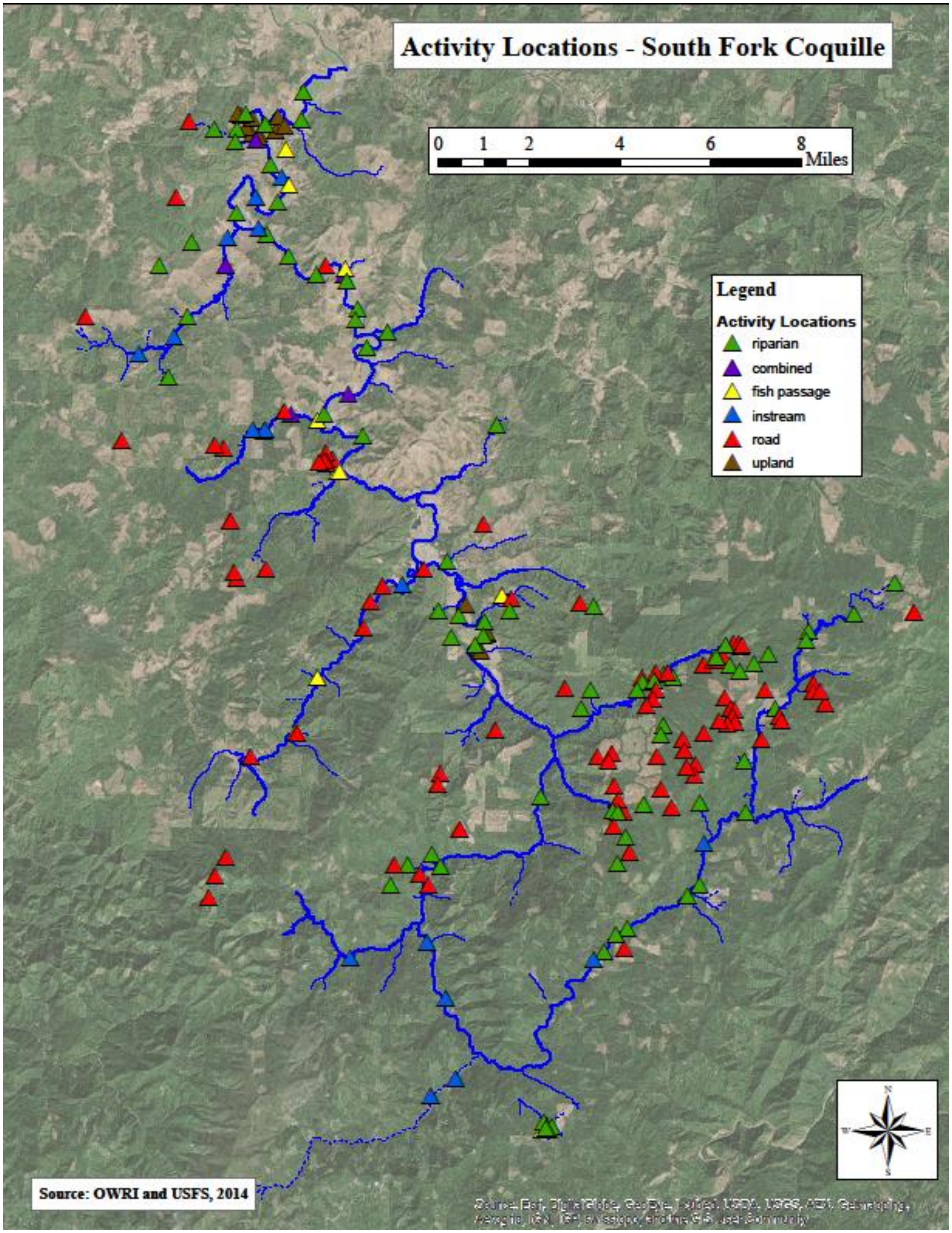


Figure 3- 1. South Fork Coquille Watershed restoration work (1995-2013), corresponds with more specific information in Table D-1 of Appendix D.

3.2.b. Mainstem South Fork Coquille River Restoration Efforts

Streambank stabilization through the use of armoring techniques (boulders) and deflector structures has been used to protect infrastructure (ex. roads and bridges) for decades. Oregon Route 542, the Powers Highway, runs between Highway 42 and Powers and is predominately along the South Fork Coquille River. The Oregon Department of Transportation (ODOT) maintains Oregon Route 542 using a variety of techniques. The downhill slope of the Powers Highway has failed several times and in several locations. Recently, in 2012, the Powers Highway was repaired in two locations (milepost 7.7 and 12.1) totaling approximately 200 feet of abatement (Sam Dunnavant, ODOT personal communication). Several projects are planned for summer 2016, including slide stabilizations between milepost 4.4 and 4.8 (three locations), culvert replacements at Rhoda and Long Tom Creeks, and additional bank stabilizations at the Burma Slide (milepost 8.1-8.4) (Sam Dunnavant, ODOT personal communication). In addition, the Port of Coquille Commission is now involved in restoration efforts along the South Fork Coquille Removal, such as pier removals.

Additional efforts on the South Fork Coquille River include the installation of riparian fencing for livestock exclusion and riparian planting. These efforts have met with mixed success depending on reach stability. Instream aquatic habitat restoration in the lower South Fork Coquille River is a difficult since stream power of the mainstem makes log and boulder placement extremely challenging. Additionally, the lower South Fork Coquille is heavily used by recreationalists (fishing and boating), and instream structures can impair navigation. Log and boulder structures have been placed on Forest Service lands upstream of Powers (Inter-Fluve, Inc., 2013; Reach 10). Logs have been trenched into existing gravel bars and heavily secured with large boulders, and others have been pinned with existing live trees along channels and side channels to create edge habitat complexity. Case studies of some of these types of restoration efforts are summarized in Section 3.3.

3.2.c. Tributary Restoration Efforts

The focus on instream habitat improvement in tributaries corresponds with dramatic declines in salmon populations recorded in the latter half of the 1900s. By the 1980s, biologists recognized the need for complex aquatic habitat (instream logs, pools, floodplain connection, sorted sediments). This led to experimentation in an attempt to replicate the natural functionality of instream wood. Today, state and federal organizations such as ODFW and National Oceanic and Atmospheric Association (NOAA) publish guides for practitioners, and numerous scientific papers have been published that demonstrate the value of instream wood placement. A wide range of efforts have been and will be undertaken in tributaries of the South Fork Coquille River. Culvert replacement, riparian planting, wood and boulder placement, road maintenance for sediment reduction, road decommissioning, livestock fencing, and invasive plant removal have all been and will continue to be utilized throughout the watershed. Case studies of some of these types of restoration efforts are summarized in Section 3.3.

3.3. Case Studies: A Review of Past Restoration Successes and Failures

The case studies below highlight the successes and failures of different types of projects in the mainstem and in tributaries. The case studies are of riparian fencing and planting and wood and boulder placement projects on the mainstem and tributaries and of a bank stabilization project on the mainstem. General information on these projects is also highlighted in Table D-1 of Appendix D.

3.3.a. Riparian Fencing and Planting on Mainstem and Dement Creek – Corbett/McWilliams/Isenhart

Project Overview

Along the South Fork Coquille River, sparse riparian vegetation and unstable banks (subject to bank collapse) have been recognized as major contributors to poor water quality and loss of agricultural land. Unstable banks experience major erosion during flood events due to excess energy in the river flows and lack of established riparian trees. The ODFW/DEQ Watershed Health Project (Coquille Watershed Association (CWA) 1996a) sought to address significant streambank and riparian damage on the mainstem South Fork Coquille and select tributaries (Figure 3-2). The project covered 23 sites in the South Fork Coquille Subbasin and was designed to block livestock access to banks, interplant in existing riparian areas, and provide off-stream water sources for livestock. This project was designed to address multiple issues, including streambank instability, lack of an established riparian zone and livestock access to sensitive areas. Major project partners were Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Environmental Quality (DEQ), Governor's Watershed Enhancement Board (now known as the Oregon Watershed Enhancement Board (OWEB)) and CWA.

Site Description

The South Fork Coquille River in the project area (Reach 3) was low gradient, with a single channel. The river was entrenched and had unstable banks that were prone to caving in during flood flow. The river terraces were disconnected, and primarily used for pasture. Riparian vegetation was limited due to clearing by landowners and lateral migration of the river channel.

Reach: 3
Township: 30S
Range: 12W
Section: 7,8,17
Year: 1996

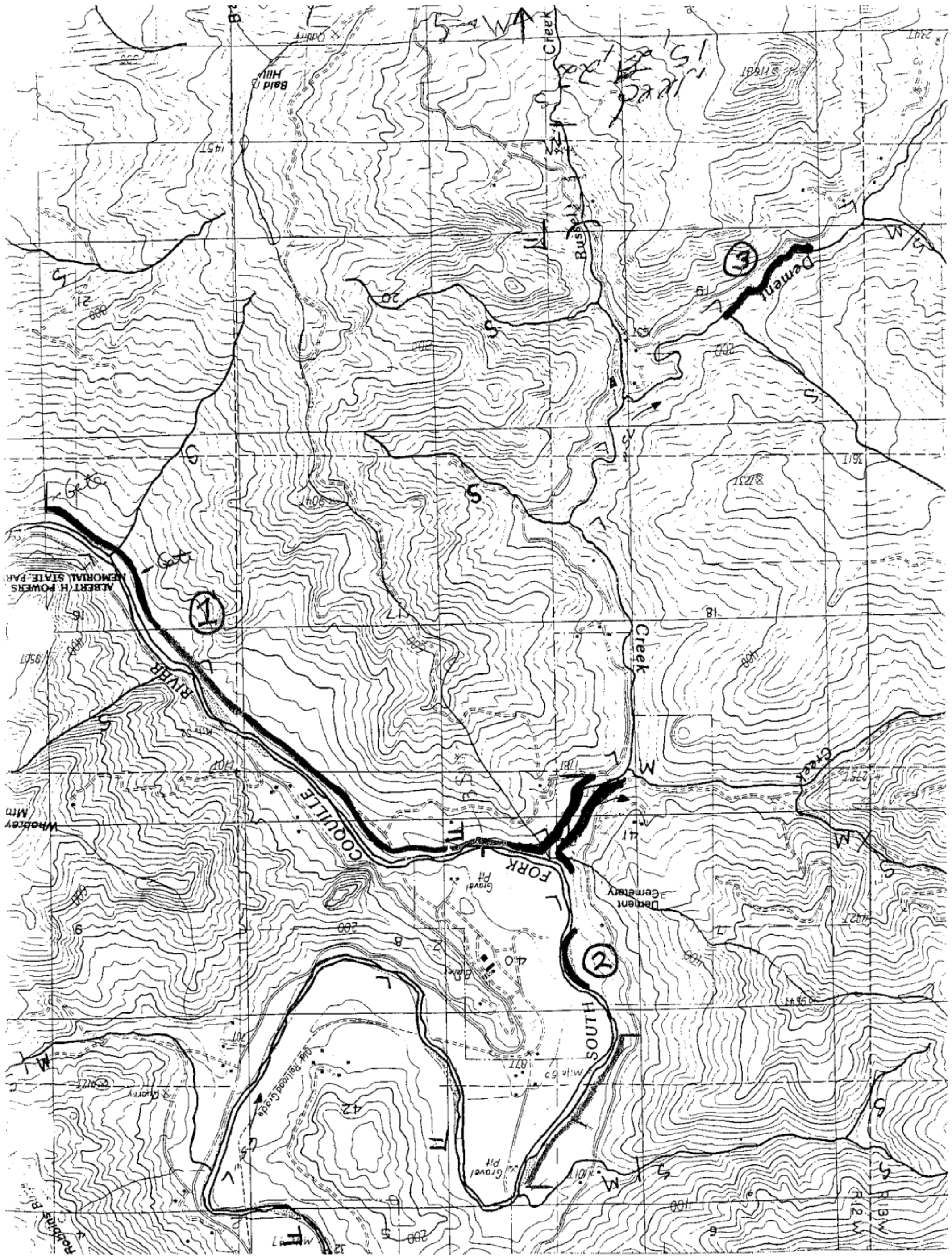


Figure 3- 2. ODFW/DEQ Watershed Health Project site locations. Number 1 is the Corbett/McWilliams/Isenhart project. Number 2 is the Isenhart Wash project. Number 3 is the Dement LW project.

Problem and Objectives

Historic land management practices have resulted in minimal riparian forest along the banks of the South Fork Coquille River. In many areas, riparian forest was cleared for pasture land. Livestock access to streambanks limits reproduction of riparian species and increases bank erosion. Long-term, gravel removal has resulted in decreased bedload, and increased erosive energy of the river, resulting in an incised channel with unstable vertical banks. The objectives of this project were to stop livestock access to the river bank, provide off-channel water sources for the livestock, re-establish a continuous riparian buffer, and reduce or eliminate bank erosion.

Restoration Project Method Implemented

Beginning in December of 1995, crews constructed 10,100 feet of fence on the South Fork Coquille River and 1,320 feet of fence on Dement Creek (Figure 3-3). The fencing consisted of: 7,013 feet of stock fencing and 4,332 feet of electric fence on Corbett's property, 594 feet of stock fencing on McWilliams property, and 2332 of stock fencing on Isenhart's property. The average setback from the channel was 70 feet on the South Fork Coquille and 60 feet on Dement Creek. Three offstream water sites were built (concrete troughs) supplied by a pasture pump, 2,500 gallon holding tank, water lines, and valves. The Corbetts contributed 174 hours of equipment and labor time clearing competing vegetation and pushing in fence posts. Inmate crews planted thousands of unrooted willow cuttings between the fence and the South Fork Coquille River in January, 1996 (Figure 3-4).

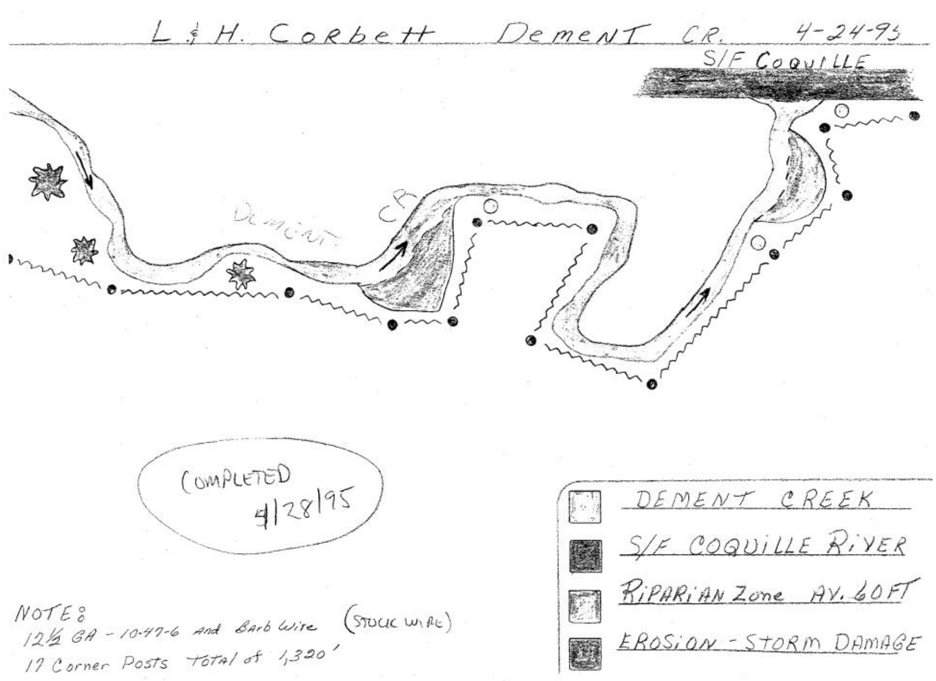


Figure 3- 3. Schematic of restoration along Dement Creek on Corbett's property.

Figure 3- 4. Crew planting willows between the fence and S. Fork Coquille River.

Results (short and long-term)

Short-term results included fencing livestock out of approximately two miles of South Fork Coquille River and a quarter mile of Dement Creek. Thousands of willows were planted in the protected riparian buffer. Crews entered the site in 2000 to remove competing vegetation. Planted willows were indistinguishable from the relict, native willows.

In 2014, the fence on the mainstem of the South Fork Coquille is nonfunctional and mostly destroyed. The river has eroded large sections of the bank leaving it vertical and unstable. This has left large gaps in the riparian buffer where the vegetation was eroded away with the bank. In retrospect, larger setbacks on the mainstem might have increased the likelihood of project success. Additionally, selecting sections of the mainstem that have achieved equilibrium increases the chance of long-term success. The fence on Dement Creek is buried in brush, but appears to be fully functional. There is a continuous, narrow riparian buffer shading the stream channel and holding the bank.

3.3.b. Riparian Fencing and Planting, Large Wood/Rock Weir Placement on Rowland Creek – Warner Ranch

Project Overview

Eroding streambanks on tributary streams due to insufficient riparian cover provide lower quality aquatic habitat and present problems for landowners. Other issues, such as poor water quality and inadequate large wood are directly related to poor riparian conditions. Livestock access to the banks increases bank erosion, adds manure to the stream, and prevents trees and shrubs from reproducing since the new plants are being eaten and/or trampled. The Riparian Restoration, Lower Coquille Tributaries Project (CWA, 1996b) fenced the livestock out of streams, provided off-channel watering for livestock, and interplanted native riparian species in existing gaps in riparian stands on 28 sites along Rowland Creek (Figure 3-5). Major project partners were Governor's Watershed Enhancement Board (GWEB, now OWEB), National Fish and Wildlife Program (now the National Fish and Wildlife Foundation), U.S. Fish and Wildlife Service, Hire the Fishers Program, Oregon Wildlife Heritage Foundation, and CWA.

Tributary streams that lack instream structure provide lower quality aquatic habitat for salmonids through lack of pools and inadequate retention of spawning gravels. A series of 25 sites had log jams installed to increase aquatic habitat complexity. Additionally, a steep cascade on Rowland Creek that presented a partial barrier to salmonid migration in years with inadequate flows was addressed through construction of a series of jump pools using eight rock weirs.

Site Description

Rowland Creek on the Warner Ranch extends from the confluence with the mainstem South Fork Coquille up to the tributary fork, and then up both the tributary and Rowland Creek (for a total of 0.9 miles). The active channel width was 55 feet; the channel gradient was 0-2%; and there was a 35 foot setback in the riparian buffer with moderate competition from invasive vegetation.

Reach:
Township: 30S
Range: 13W
Section: 33
Year: 1996

Problem and Objectives

Inadequate riparian vegetation and livestock access to the stream were impacting stream health and aquatic habitat quality in Rowland Creek on the Warner Ranch. Objectives included blocking all access to the stream for livestock, providing alternate sources of water for livestock, filtering animal wastes, and eroded soil from overland flows into the stream, and increasing riparian shade.

Lack of structure in the stream channel resulted in inadequate spawning gravel retention and a lack of complex pools. Objectives included retention of spawning gravels, creation of pools, creating backwater areas, and improving fish passage.

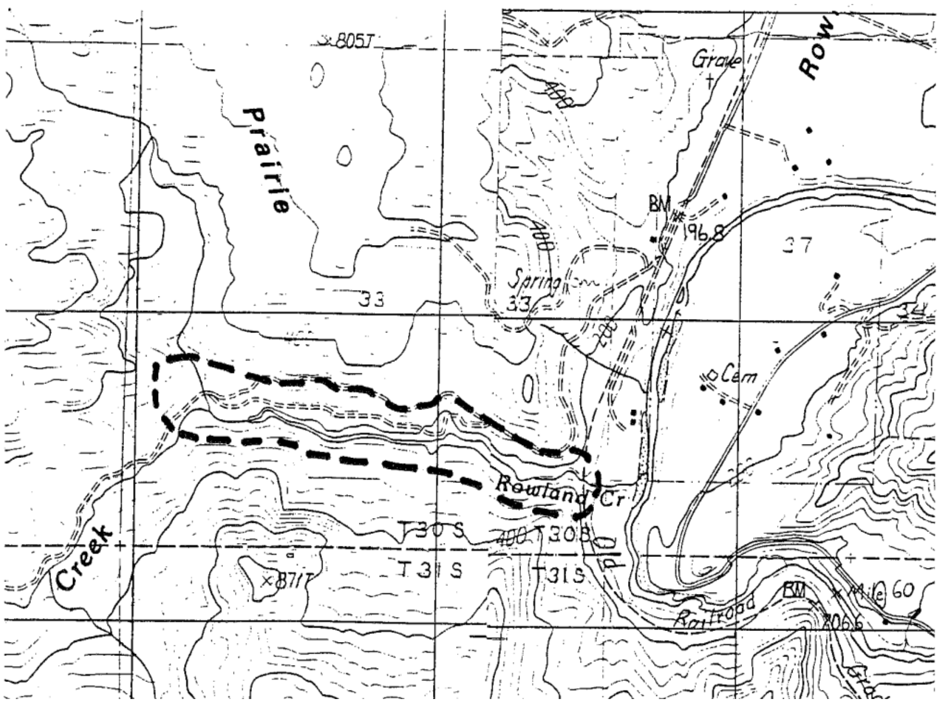


Figure 3- 5. Location of project on Rowland Creek.

Restoration Project Method Implemented

The riparian area of Rowland Creek and a tributary were fenced with 6,380 feet of woven wire topped by two strands of barbed wire and including three gates. Off stream water opportunities were developed for the livestock using a storage tank filled from a spring and 3,000 feet of water lines to two troughs. Riparian trees including Douglas fir, Western red cedar, Western hemlock, big leaf maple, and Oregon myrtle were planted in the gaps between existing riparian stands (see Appendix A for scientific names).

The instream portion of the project included the construction of 25 log structures each with 3-5 key logs/structure, some smaller logs (total 150 logs) and additional rootwads (total 33 rootwads) (Figure 3-6). The log jams are either full-spanning structures which span the entire stream, or margin-associated structures, which are along one side or the other of the stream. Jump pools to aid salmonid passage past the steep cascade were constructed using eight rock weirs.

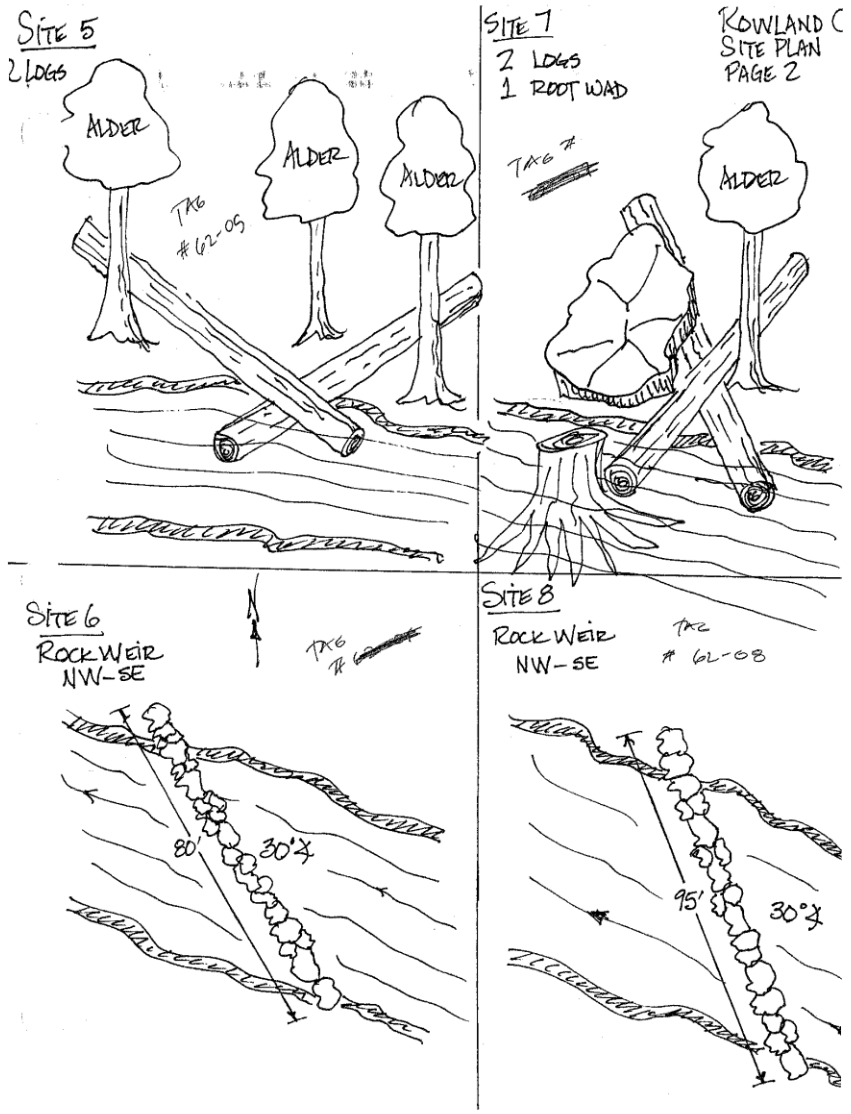


Figure 3- 6. Diagrams of log and weir structures on Rowland Creek.

Results (short and long-term)

After one year, the livestock fences were functional with minimal damage to the fencing. Watering systems for the cattle were all functional. Riparian planting survival was high with 90% canopy closure over 40% shrub cover and 60% grass cover. Overstory species included Douglas fir (*Pseudotsuga menziesii*) and grand fir, red alder, big leaf maple, myrtle, vine maple, Oregon oak (*Quercus garryana*), tanoak, and Oregon ash. Understory species included chittum bark, thimbleberry (*Rubus parviflorus*), ocean spray, blue huckleberry (*Vaccinium oratum*.), and poison oak (*Toxicodendron diversilobum*) (see Appendix A for scientific names not included here). Invasive vegetation competition for the plantings was low.

The 2000 monitoring visit found all 25 log structures intact. The structures had recruited some additional wood, formed deep pools for summer refugia, retained spawning gravels, and created backwater areas for winter rearing habitat. CWA and ODFW staff briefly visited the site in Fall 2012 (Figure 3-7). Some of the placement sites have moved/shifted, while others are contributing significantly to aquatic habitat complexity in Rowland Creek. A more thorough evaluation of this project is needed.

Figure 3- 7. Rowland Creek wood placement site in Fall 2012.

3.3.c. Large Wood Placement on Dement Creek – Isenhart - (South Fork Coquille Channel and Fish Habitat Restoration)

Project Overview

Dement Creek is a major tributary to the South Fork Coquille River and is water quality limited for temperature, sediment and bacteria (Appendix B and DEQ, 2012b). Dement Creek has been heavily impacted by anthropogenic activities such as splash damming, riparian logging, and stream cleaning, which has greatly simplified the aquatic habitat and removed instream structure. Nine large wood structures were placed in a 700 foot reach of Dement Creek in 2009 (Figure 3-2). Project partners included the CWA, U.S. Fish and Wildlife Service, and Oregon Department of Fish and Wildlife.

Site Description

In the project reach, Dement Creek displayed limited large wood, pool habitat and overall pool complexity, available spawning habitat, with a majority of streambed consisting of bedrock and small boulders. The riparian corridor had areas of sparse vegetation consisting of conifers, hardwoods, dense understory shrubs and invasive plant species.

Reach: 3
Township: 30S
Range: 12W
Section: 18, 19
Year: 2009

Problem and Objectives

Splash damming and stream cleaning have resulted in a stream channel with very little structural complexity, loss of stream connectivity, higher velocities and channel downcutting where bedrock is not present. For salmonids, this means inadequate or poor quality spawning habitat, rearing habitat (summer and winter), and a lack of cool water refugia. The removal and/or lack of large wood decreases bank stability and may case the stream to change direction after wood removal resulting in the stream cutting into the streambed, disconnecting the stream from its floodplain.

Project objectives include increasing channel width/depth ratios, improving quantity of spawning gravel, increasing total pool area and residual depth, increasing instream large wood volume, and increasing number of complex pools.

Restoration Project Method Implemented

Nine log and boulder structures were placed in a 700 ft. section of Dement Creek. Each structure consisted of 3-5 key logs, some smaller logs, and boulders larger than one cubic yard. A total of 37 key logs and 37 smaller logs were used to construct the nine log structures (Figures 3-8 and 3-9). Key logs were 28-36 inch diameter and 55-65 ft. long while the smaller logs were less than 24 inch diameter and a minimum of 33 ft. long. Bank armoring was installed at the nine structures to help them withstand flood events. Project design was based on the Oregon Aquatic Habitat Restoration and Enhancement Guide for large wood placement.

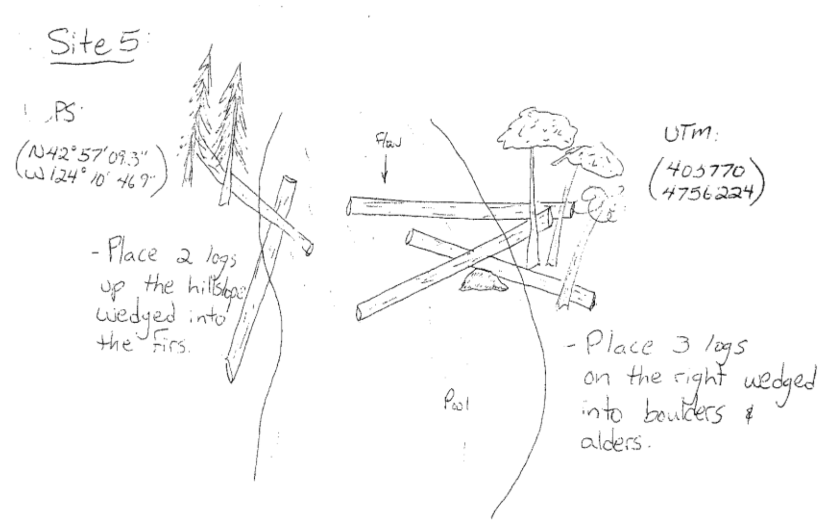


Figure 3- 8. Diagram of Log Structure 5 on Dement Creek.

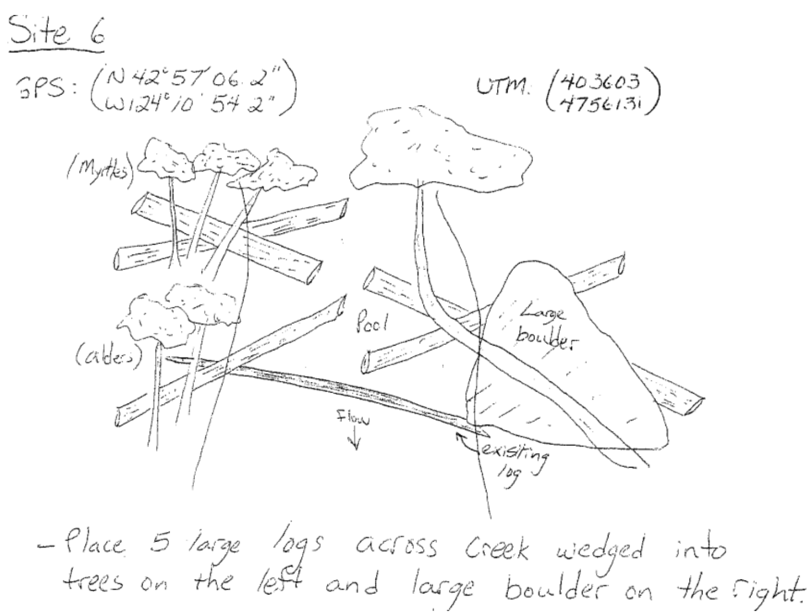


Figure 3- 9. Diagram of Log Structure 6 on Dement Creek.

Results (short and long-term)

After one year, all nine sites were intact and stable. No logs have been lost from any of the structures. Gravel was accumulating around the structures, and pools were beginning to develop. No maintenance was needed to keep the structures functioning properly.

After four years, all nine structures were stable and performing well. The project had withstood a 20 year flood event. Additional wood was being trapped, backwater pools were forming and secondary channels were developing. The 2013 ODFW spawning survey found Coho Salmon and Cutthroat Trout in the project reach.

In 2014, eight structures are intact and functioning as designed. The full width structures are trapping wood, retaining gravel and scouring pools. The channel margin structures are creating backwater eddies for refugia from flood flows. All structures provide cover for juvenile salmonids from predators. Two key logs that moved downstream have created a structure above the confluence with Russell Creek that is highly functional and stable.

3.3.d. Bank Stabilization on the Mainstem – Isenhart Wash

Project Overview

The South Fork Coquille River in Reach 3 had an incised channel and sections of vertical banks that often collapse during flood events. The Natural Resource Conservation Service designed a project to demonstrate the use of bioengineering and erosion control fabric as an alternative to riprap for treating this type of bank failure. A successful project would reduce bank erosion, revegetate denuded banks with native riparian species, add complexity to the river channel and increase public awareness of alternative bank stabilization techniques. Major project partners included Natural Resource Conservation Service, Oregon Department of Environmental Quality, Coos Soil and Water Conservation District, and CWA, 1996c).

Site Description

This project included six hundred feet of bank on one side of the mainstem South Fork Coquille River near Broadbent. River gradient at this location is 0-2% with approximately 120 ft. wide incised channel and vertical banks.

Reach: 3
Township: 30S
Range: 12W
Section: 7
Year: October 1996

Problem and Objectives

Active erosion of unstable banks along the incised channel of the South Fork Coquille River was adding large quantities of sediment to the river and causing loss of pasture land.

The objectives were to reduce or eliminate bank erosion, reestablish riparian vegetation, add complexity to the river channel, improve water quality through reducing sediment and turbidity, improve fish habitat, and raise public awareness of alternative bank stabilization techniques.

Restoration Project Method Implemented

Project methods consisted of: resloping the bank to a 2:1 slope, installing willow facines in trenches across the slope, covering slopes with Enkamat erosion control matting (geotextile product), planting willows and seeding bare soil with rye grass, fencing project with a 50 ft. setback to exclude livestock from the riparian area, maintaining plantings, and maintaining fences to exclude cattle and sheep. (Figure 3-1)

Results (short and long-term)

After one flood season there were no blowouts of the main slope, although some minor erosion did occur. There was approximately 60-70% willow survival with moderate competition from invasive vegetation. Willows provided approximately 60% shrub cover, with 40% grass cover on the slope.

Figure 3- 10. Site photos shortly after completion of bank stabilization project at Isenhart Wash.

In 2004, the project was considered partially successful. The slope had some erosion that needed to be addressed. The fence was intact and functioning, the willow plantings had survived, and planted trees were indistinguishable from relict, native trees.

In 2014, the project is no longer successful. Two thirds of the site consists of vertical, unstable banks that are actively eroding. In one case active erosion extends under the fence leaving 25 feet of fence hanging in the air. Otherwise, the fence is 95% intact and well maintained. The primary vegetation on the eroded portions of the site is Himalayan blackberry and grass. A small section of the project area contains 20-25 ft. tall willows and several dying alder trees.

3.3.e. Wood and Boulder Placement on Tributary – Rock Creek above Powers

Project Overview

Implemented in two phases, the Restoring Salmonid Habitat and Stream Dynamics in Rock Creek project targeted aquatic habitat deficiencies through the placement of logs, rootwads and boulders on lower Rock Creek, a tributary of the South Fork Coquille within the Rogue River-Siskiyou National Forest. Wood and boulders had been removed from Rock Creek due to anthropogenic activities such as riparian logging, placer mining, and stream cleaning. These activities significantly reduced aquatic habitat and riparian complexity, impacting components such as shade/cover, channel sinuosity, off-channel/floodplain habitat and gravel recruitment. Phase I (2008-2009) consisted of the construction of 22 log/boulder structures placed over 0.5 miles of instream habitat (CWA, 2012a). Phase II (2010-2011) consisted of 75 logs and rootwads and 74 boulders (1-1.5 cu. yd. each) over 10 sites, treating an additional 0.5 miles of instream habitat (CWA, 2012a). All rootwads, logs, and boulders were placed using excavators. Major project partners in this project were the CWA, U.S. Forest Service, and Ecotrust.

Site Description

Rock Creek is a relatively low gradient (approximately 1-2% in treatment reach) tributary of the upper South Fork Coquille River (entering the river in Reach 10) characterized by alluvial gravel deposits and mobile bedloads. Bankfull widths in the treatment reach are approximately 75 ft.. The U.S. Forest Service is the landowner of the entire 7th field hydrologic unit and manages the riparian areas for fish and wildlife production and protection.

Reach:
Township: 33S
Range: 11W
Section: 19
Year: 2008-2009 (Phase I), 2010-2011 (Phase II)

Problem and Objectives

Historic land management activities such as logging, mining, and stream cleaning have simplified aquatic and riparian habitat. The valley bottom road along the South Fork Coquille River has fragmented aquatic habitat and limited aquatic organism passage, restricted water and substrate movement, and interrupted hydrologic connectivity. Simplified habitat is not able to support as many juvenile fish and aquatic invertebrates when compared to more complex habitat. Additional channel roughness, provided through the thoughtful placement of rootwads, logs, and boulders, decreases stream energy allowing for the collection of sediment and giving juvenile fish cover during high flows. Instream complexity promotes floodplain interaction and off-channel habitat activation, which dissipates stream energy and allows fish and other aquatic species additional options for escaping high water conditions.

Numerous objectives were listed by project planners, including: improved instream structure and complexity, improved floodplain interaction, increased gravel recruitment, improved spawning and rearing habitat, increased pool complexity, and improved summer and winter juvenile habitat (CWA, 2012a).

Restoration Project Method Implemented

Phase I was planning and implementing 22 rootwad, log, and boulder instream structures (Figure 3-11). Two of the most common designs used in Phase I was log cribs and log rakes. Designs were aimed at collecting organic material as it moved downstream (logs, branches, leaves), provide cover for juvenile fish, collecting bedload, and promoting floodplain interaction.

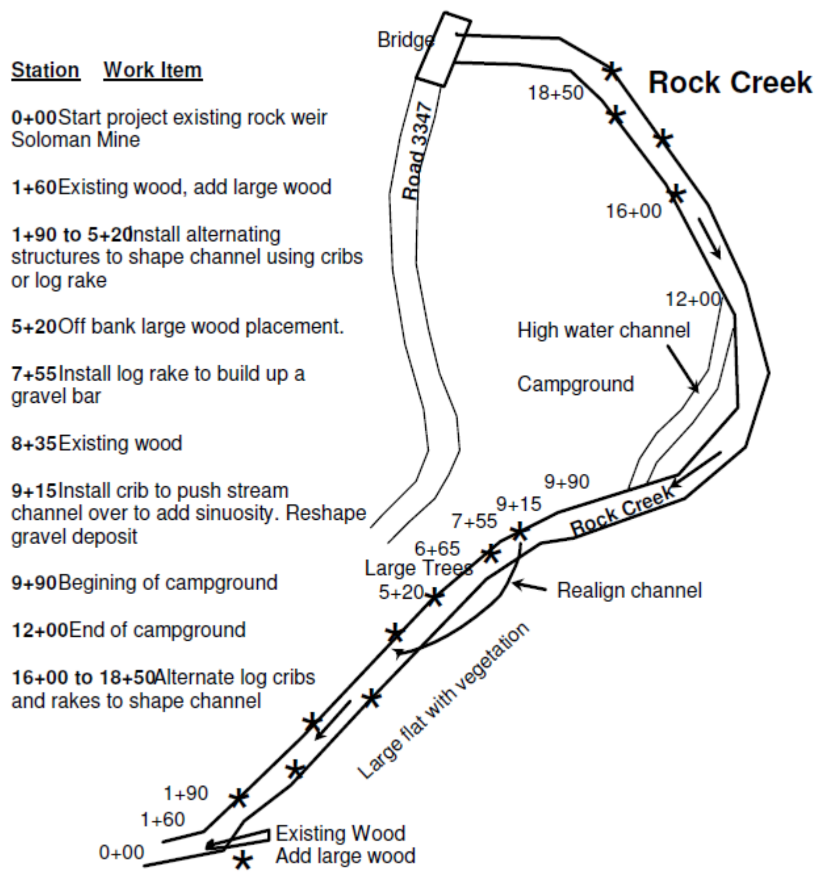


Figure 3- 11. Restoring Salmonid Habitat and Stream Dynamics in Rock Creek, Phase I.

Phase II continued project objectives defined in Phase I, relying on augmentation of natural accumulations of woody material to guide additional wood placements (Figure 3-12). Additionally, Phase II supplied additional channel roughness and contained specific designs to scour pools for both summer and winter juvenile fish habitat. Phase II included the placement of 75 rootwads and logs, as well as 74 boulders that were approximately 1-1.5 cu. yd. each.

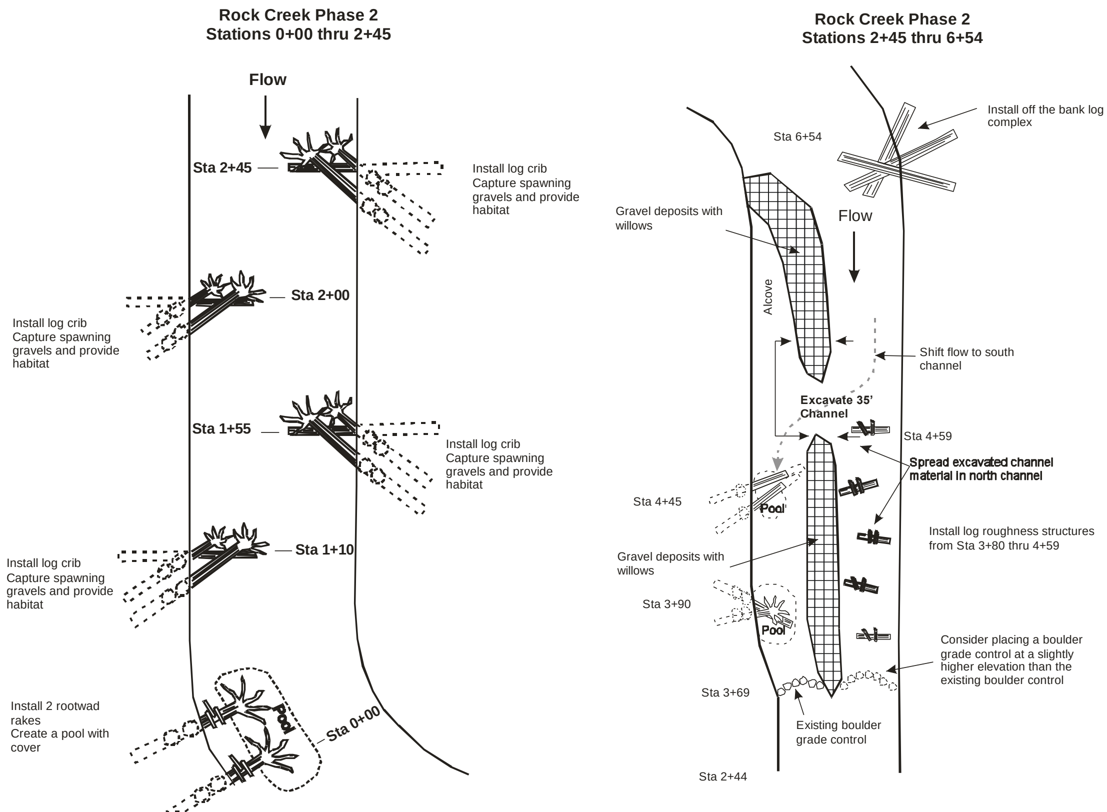


Figure 3- 12. Restoring Salmonid Habitat and Stream Dynamics in Rock Creek, Phase II.

Results (short and long-term)

The log cribs, rakes, and boulders have not been modified or needed maintenance since the last Status Report, and they continue to recruit gravel, offer refuge and cover, and provide complexity and nutrients. The off-bank log complexes are helping to shape and direct the stream (Figure 3-13), although the season was unusually dry with low flows so the next high flows to occur will be observed and interactions noted. The log rakes are serving their purpose in building gravel bars and recruiting large wood (CWA, 2012b).

The additional materials placed in 2010 in the 3 underperforming sites (located between 1+90 and 5+20) to buttress the original materials are functioning better than expected. The enhanced side channel has started to accumulate gravel and large wood, in addition to providing refuge and complexity (CWA, 2012b).

It is too early to determine the effectiveness of this project. Episodic events, largely driven by rainfall or rain on snow events, work to redistribute bedload and woody material. Material may move through a stream in an irregular manner, affected by wood, boulders, infrastructure, channel form, and numerous other factors upstream of the project site. Early results seem to indicate that this project is addressing nearly all of the objectives outlined in the original grant application.

Figure 3- 13. Rock Creek project immediately post-implementation (left photo). Rock Creek project during winter flows 2010 (right photo).

3.3.f. Wood and Boulder Placement on Mainstem – South Fork Coquille River at Daphne Grove Campground

Project Overview

Designed to improve degraded instream habitat, the South Fork Coquille River Large Wood Placement/Slope Stability project utilized wood and boulder placements to address several aquatic habitat deficiencies. Placements began in 2012 and were completed in 2013. Both excavators and cable yarding equipment were used to place whole and cut trees, as well as boulders. Major project partners included the U.S. Forest Service, CWA, Oregon Department of Fish and Wildlife, and Ecotrust.

Site Description

The project site is located on the mainstem South Fork Coquille River above Powers, at River Mile 22.8. The mainstem of the South Fork Coquille is adjacent to paved Forest Service roads. Alluvial bedload consists of sand, gravel, cobble, and boulders (depending on localized hydrology) with numerous gravel bars. Active channel width at project location is over 100 feet at this location is approximately 90 feet.

Reach: South Fork Coquille above Powers (Reach 10).
Township: 33S
Range: 11W
Section: 7
Year: 2012-2013

Problem and Objectives

Stream cleaning and the lack of connection to an intact riparian corridor due to past land management activities has decreased large wood recruitment resulting in depletion of slow water refugia, loss of gravel deposition, rearing pools, backwater, side channels, bank stabilization, and overall stream complexity. Construction of Forest Road 33 has either replaced the riparian area or resulted in the reduction of large conifers in the riparian stands. The South Fork Coquille River is disconnected from its riparian community, presenting barriers for wood and gravel recruitment from upslope areas. Since the South Fork Coquille River is a large and energetic stream, for any instream wood to result in significant stream channel changes it must be very large and dense.

Project planners hoped to accomplish several specific objectives, including: increasing wood volume and total key pieces, increasing pool area and residual pool depth, increasing the number of complex pools and increasing the percentage of gravel contained in riffles (CWA, 2012b). During project implementation, managers also sought opportunities to increase edge habitat complexity (increasing cover for juvenile fish during high flows), increased side channel utilization and reducing stream energy by slowing flow through the introduction of instream habitat roughness features.

Restoration Project Method Implemented

This project constructed large wood complex sites utilizing wood sources upslope and adjacent to the project site. Roadside hazard trees were utilized for this project and identified by Forest Service engineers (Figure 3-14). All trees were either whole trees pulled down (in order to include the rootwad as part of the instream placement) or cut trees and then pulled down by a cable yarder subcontracted to Blue Ridge Timber (Figure 3-14). During 2012, the CWA restoration crew hauled trees from within the watershed, staged them near the project site, and placed them using an excavator. Trees were buried on the gravel bar with rootwads exposed. Cut logs without rootwads were buried with boulders and gravel on high spots on the gravel bar in various formations, namely rakes (Figure 3-15). During 2013, Blue Ridge Timber cut large hazard trees adjacent to the project site and placed them using a cable yarder. Whole-length trees were pulled in to the opposite bank. All trees were either locked in place by pinning them with live standing trees in the riparian zone or pulled onto the floodplain with a nominal amount of exposure within the active channel width. One large log was placed in the main thalwag when it fell and moved over the road and directly into the river in a position that would have been a logical addition to the project. This opportunistic placement was fortunate and reinforced with multiple boulders moved from nearby (Figure 3-16).

Figure 3- 14. Upslope hazard tree with rootwad moved via 4x4 dump truck during 2012 for the S.F. Coquille at Daphne Grove Campground restoration project. Location of hazard trees limited movement of whole trees.

Figure 3- 15. Smaller cut logs buried on gravel bar in rake formation during 2012. Structure is designed to accumulate wood in the South Fork Coquille River at Daphne Grove Campground.

Results (short and long-term)

Since this project was very recently implemented, it is difficult to measure overall project results. Wood placements did interact with winter flows but have not trapped a great deal of material as of yet (Figure 3-17). It might be several years before tangible results are realized. Project managers are confident that slowing flows and providing winter refugia objectives have been met. The original Whole Watershed Restoration Initiative (WWRI) grant application acknowledged that it may take 5-10 years for some of the objectives to be met (CWA, 2011). It does not appear that significant sediment sorting is occurring in the side channel. None of the project logs have left the site, so the project has been successful in that regard. Managers will continue to monitor this wood placement project, hoping to improve on subsequent projects.

Figure 3- 16. Log placement on Road 33 side, in main flow of S.F. Coquille at Daphne Grove Campground. Picture taken immediately after placement in September 2013 (left photo). Log placement on the South Fork Coquille at Daphne Grove Campground during October 2013 high water (right photo).

Figure 3- 17. Log placement on South Fork Coquille River at Daphne Grove Campground in early spring flow, April 2014.

Chapter 4: Geomorphic and Hydrologic Analysis

4.1 Overview of Channel Evolution and Stream Classification

4.1.a. Channel Evolution

The hydraulics of streams and rivers is complex. Non-stop and concurrent changes occur between discharge, channel width and depth, stream channel slope, substrate, sinuosity, sediment supply, and sediment size. Models such as Simon and Rinaldi's (2006) stages of channel evolution model and stream typing systems, such as the Rosgen Classification of Natural Rivers (Rosgen, 1996) can describe and group like hydraulic variables of natural streams and rivers. Further, restoration guidelines are developed by measuring stream geomorphological relationships of reference reaches and transferring the information by stream type to a reach in an altered condition. This then becomes a template for restoration.

Simon and Rinaldi (2006) contains a model of stream channel evolution for interpretation of past, present, and future channel processes (Figure 4-1). Channel evolution is often triggered when excess stream power or flow energy occurs relative to the sediment load (sands and gravels) delivered from upstream; when a geomorphic threshold is reached, a shift will occur in the channel evolution (Simon and Rinaldi, 2006).

Simon and Rinaldi's (2006) model describes six stages of channel evolution (Figure 4-1). Stage I is the equilibrium stage in a predisturbed condition. Stage II is the disrupted channel, an instantaneous condition. Rapid channel degradation of the channel bed occurs, in Stage III, as the channel begins to adjust to these changes. Degradation lowers channel gradients and therefore reduces the available stream power for given discharges with time. Concurrently, bank heights are increased and bank angles are often steepened by undercutting and bank failures near the base of the bank. The degradation stage (Stage III) is directly related to destabilization of the channel banks and leads to channel widening by mass-wasting once bank heights and angles exceed conditions of critical shear-strength of the bank material, which is Stage IV. Stage V, the aggradation stage, occurs as degradation migrates further upstream because the flatter gradient at the degraded site is unable to transport the increased sediment loads coming from degraded reaches upstream. Riparian vegetation becomes established on low-bank surfaces during Stage V which provides roughness that enhances further deposition, serving as a positive-feedback mechanism. These milder aggradation rates indicate that recovery of the bed will not be completed and that a new dynamic equilibrium (Stage VI) will take place through: (1) further bank widening and flattening of bank slopes; (2) the establishment and growth of riparian vegetation which adds roughness, enhances bank accretion, and reduces stream power; and (3) further gradient reduction by meander extension and elongation.

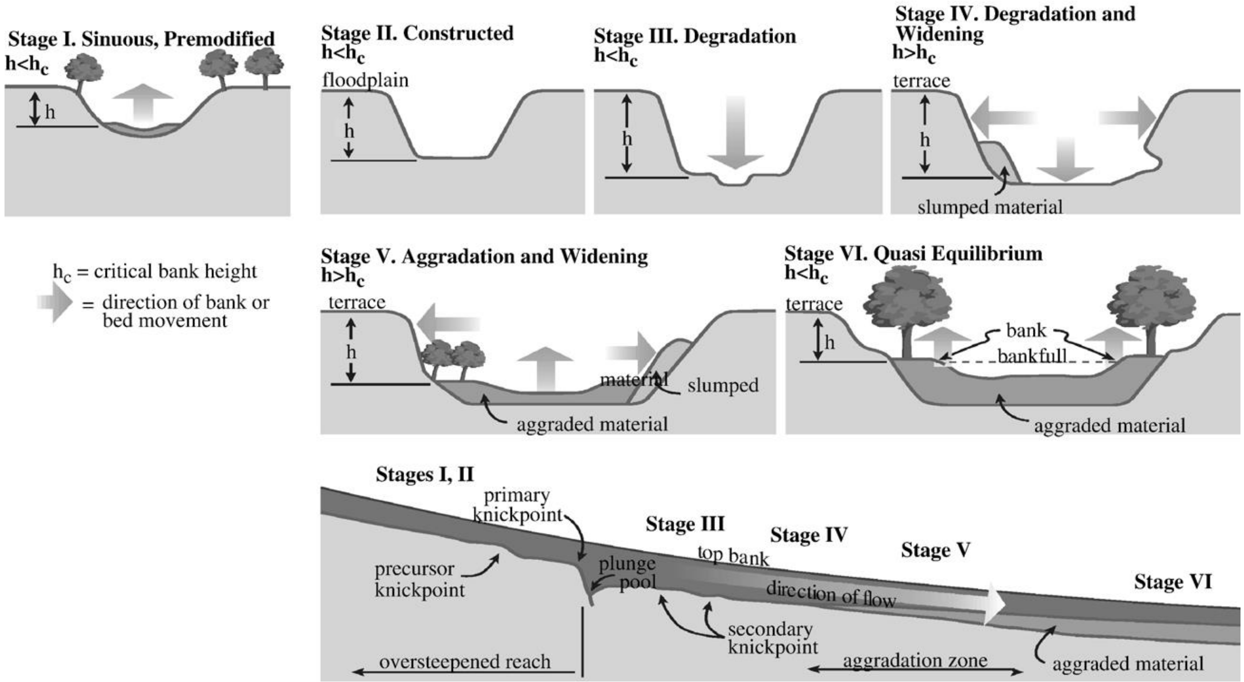


Figure 4- 1. Stages of evolution (Figure 7 in Simon and Rinaldi, 2006; modified from Simon and Hupp, 1986).

Other researchers have suggested that there are two more changes occurring in the channel evolution model. Stage 7, late stage evolution, is when the channel is laterally active with frequent floodplain connection as it is developing a sinuous course (Cluer and Thorne, 2013). This promotes bar accretion at inner margins and scour and renewed bank retreat along outer margins (Cluer and Thorne, 2013). Stage 8, anastomosing, occurs when instead of a single channel being present, a channel braids into a channel network that is frequently flooded and may support wetlands (Cluer and Thorne, 2013). Stage 7 and 8 are both types of late stage evolution, but one has a single channel and the other has multiple channels. Late stage evolution characteristics of a previously incised channel are shown in Figure 4-2. Figure 4-3 shows the same Stages 1-6 as Simon and Rinaldi (2006), but combines that with the concepts of the late stage evolution model (Figure 4-2) and adds a pre-disturbance stage (Stage 0) and the two late-stage evolution stages (Stages 7 and 8) (Cluer and Thorne, 2013). Figure 4-3 also includes the dominant process present (narrowing, widening, aggradation, degradation). Note that Simon and Rinaldi (2006) uses Roman numerals and Cluer and Thorne (2013) use numbers to depict the same changes interchangeably.

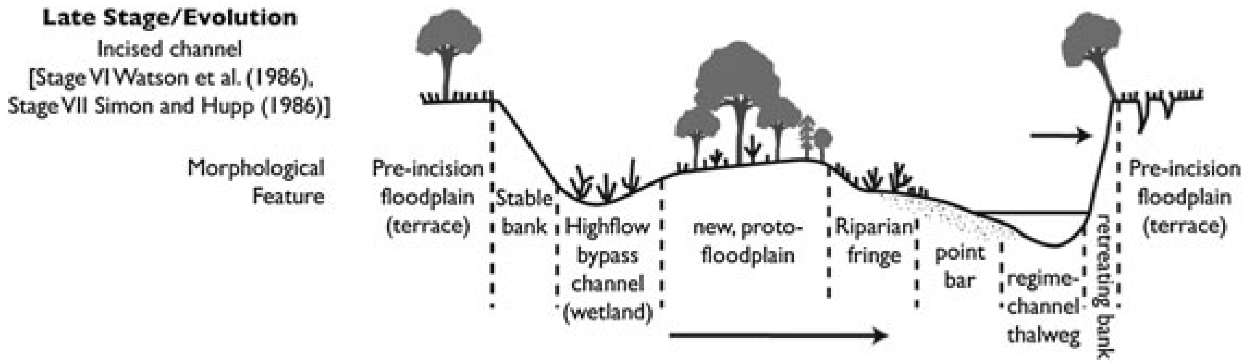


Figure 4- 2. Late stage channel evolution (Stage 7) development (Figure 3 in Cluer and Thorne, 2013; modified from Thorne, 1999).

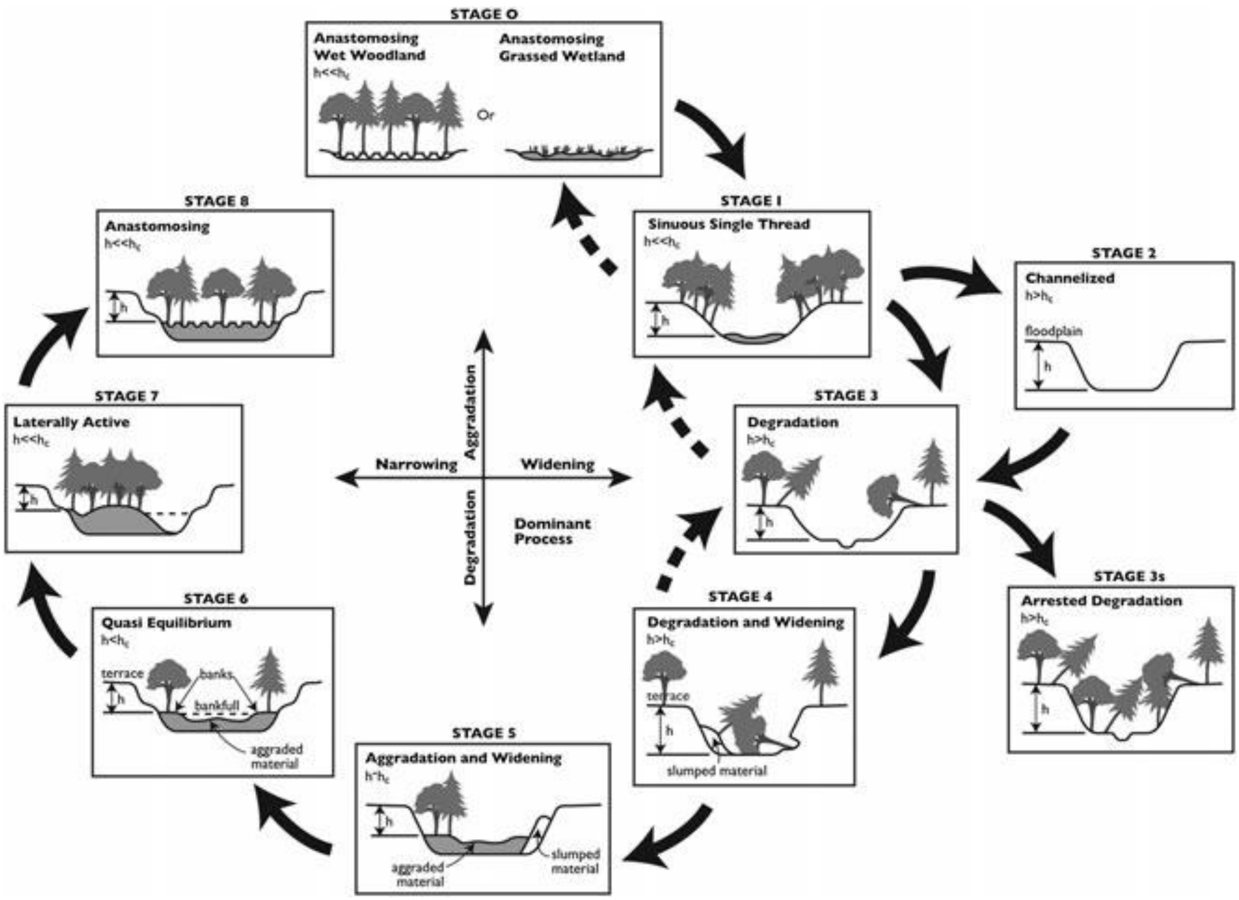


Figure 4- 3. Stream evolution model based on Simon and Rinaldi (2006) and Figure 4-2 inserting a pre-disturbance stage (Stage 0) and two late-stage evolution stages (Stages 7 and 8) (Figure 4 in Cluer and Thorne, 2013).

Table 4-1 and 4-2 further describe the channel evolution model, with physical and vegetative attributes in Table 4-1 and habitat and ecosystem benefits in Table 4-2.

Table 4- 1. Physical and vegetative attributes for each stage in the stream evolution model (Table 2 in Cluer and Thorne, 2013).

Table 2. Physical and vegetative attributes of each SEM Stage.

SEM Stage		Physical Attributes			Vegetation Attributes
		Hydrologic Regime	Hydraulics and Substrate	Dimensions and Morphology	
0. Anastomosing. Dynamically meta-stable network of anabranching channels with vegetated islands supporting wet woodland or grassland.		Floods diffused over the full width of the floodplain so flood peaks are maximally attenuated. Flood pulses diffused and subdued. High water table and close connection between stream flow and ground water ensures reliable base flows and continuous hyporhesis, though flow in smaller anabranches may be ephemeral.	Multiple channels provide maximum in-channel hydraulic diversity through partition of discharge between branches that widens range of in-channel depth/velocity combinations. Anabranches create multiple, marginal deadwaters. Wide range of substrate grain sizes arranged into numerous, well-sorted bed patches.	Multiple anabranches, islands and side channels maximize. Morphological features abound in-channel and on the extensive and fully connected floodplain, providing a high capacity to store sediment and wood and supporting diverse wetlands. Bank heights are low with stability enhanced by riparian margins, but some river cliffs are generated by localised erosion. Network and floodplain are highly resilient to disturbance, buffering the system.	Frequent, small channel adjustments and high, reliable water table create ubiquitous settings for proliferation and succession of aquatic, emergent, riparian and floodplain plants. Wet woodlands on islands and floodplain supply and retain wood, and widespread vegetation proximal to channels produces abundant leaf litter.
Single Thread Channels	**1.Sinuous, single-thread .** Stable and laterally active. Sediment sorting and transfer.	Floods up to bankfull discharge retained in-channel reducing attenuation. Larger floods still spill to floodplain, attenuating their peaks. Close connection between groundwater and stream flow ensures reliable base flows and good hyporhesis.	Range of in-channel depth/velocity combinations up to bankfull flow provides moderate hydraulic diversity and frequent deadwaters along remaining channel boundaries. Substrate sorting varies between thalweg and alternate or point bars, with different degrees of armoring. Variation in bed morphology continues to supports a high degree of substrate patchiness.	Wetted area relative to flow, shoreline length and complexity decrease due to switch to single channel. Though bedforms and bars remain widespread, frequency of islands, confluences and diffluences is greatly reduced, adversely affecting capacity to store sediment and wood. Higher banks are less stable with river cliffs found along outer margins of bends. Floodplain extent and connectivity undiminished, but number of side channels and functionality of connected wetlands reduced.	Decreases in hydraulic and morphological diversity trigger reductions in quantity and quality of aquatic, riparian and, especially, emergent plants. Floodplain communities remain diverse, but transition from wetland to more terrestrial assemblages. Reductions in extent of woodlands due to switch from multiple to a single channel decrease recruitment of wood and leaf litter.
	2. Channelised. Re-sectioned land drainage, flood control, or navigation channels.	Flood flows retained in-channel up to design discharge, enhancing flood pulses. Flood attenuation reduced. Efficient drainage speeds post-flood recession and lowers groundwater, so base flows and hyporhesis are impaired.	Artificially high in-channel discharge capacity coupled with uniformity of depth/velocity combinations reduces hydraulic diversity and compromises functionality of any marginal deadwaters. Bed substrate scoured, with sorting impacted and patchiness reduced through extreme	Channelisation reduces wetted area, shoreline length and complexity relative to flow. Some bedforms and bars remain but islands, side channels, and confluences/diffluences are eradicated. Capacity to store sediment and wood reduced, or eliminated by channel maintenance. Banks stable or revetted, with river cliffs eliminated. Extent, connectivity and functionality of	Aquatic and emergent plants destroyed during construction with recovery limited to patches and narrow belts. Riparian plants only contribute wood and leaf litter if some of riparian corridor is left in place. Floodplain vegetation communities disconnected from channel may transition
	3. Degrading. Incising and abandoning its floodplain. Banks stable geotechnically.	Concentrates progressively greater flood peaks in-channel, further amplifying flood pulse Flood attenuation ineffective. Groundwater recharge is minimal, making base flow unreliable. Hyporheic zone damaged or destroyed by scour at bed and bank toes.	Bed lowering, removal of bars and riffles and scour at bank toes reduces hydraulic diversity means there are few, if any, marginal deadwaters. Bed substrate continues to be scoured, with sorting impacted and patchiness reduced through extreme armoring or paving.	Degradation reduces wetted area, shoreline length and complexity relative to flow compared to Stage 1. Bedforms, bars and islands scoured, confluences/diffluences eradicated and side channels, floodplain and wetlands abandoned. Capacity to store sediment and wood effectively lost. Banks mostly stable with local river cliffs. Functionality of the riparian zone is diminished due to reduced connectivity with channel.	Aquatic and most emergent plants destroyed by incision; only seasonal and annual species remain. Riparian vegetation undercut and increasingly unstable leading to artificially elevated inputs of wood. Input of leaf litter, seeds and propagules continues, but retention reduced. Floodplain vegetation stressed due to lower water table.
	3s. Arrested degradation. Confined or canyon-type channels.	Concentrates a wide range of flood peaks, providing no effective flood attenuation and maximal flood pulse effects. Groundwater recharge is minimal, base flow unreliable and hyporheic zone remains damaged or destroyed.	Similar to Stage 3, though there may be some limited recovery of hydraulic diversity due to presence of invasive or remnant riparian plants and accumulation of log jams formed by tress that have fallen into the degraded channel. Limited sediment retention, sorting and patch development.	Natural or artificial stabilization locks in dimensions and morphology developed in Stage 3. Limited capacity to store sediment and wood once degradation ceases. Banks mostly stable but extent of river cliffs may increase. Functionality of the riparian zone remains diminished and channel is permanently disconnected from its floodplain and wetlands.	Relative stability allows for early succession in emergent and riparian plant communities, improving supply of leaf litter. Wood recruitment continues, limited by the proximity, width and contiguity of woodlands on surrounding floodplain and terrace surfaces.
	4. Degradation and widening. Incising with unstable, retreating banks.	Concentrates an extreme range of flood peaks, negating flood attenuation and further amplifying flood pulse effects. Groundwater recharge, base flow generation and hyporheic connectivity are all dysfunctional.	Hydraulic diversity remains low due to channel scour and efficient downstream transport of woody debris. Deadwaters continue to be absent or dysfunctional. Bed scour continues to adversely impact substrate sorting and patchiness.	Sediment inputs from bank retreat initiates limited bedform and bar development, but mass failures eliminate stable banks and increase the extent of river cliffs that destroy riparian margins. Wetted area, shoreline length and complexity relative to flow all remain low. No recovery of capacity to store sediment and wood, and floodplain still disconnected.	Aquatic plant community remains dysfunctional due to on-going bed degradation and riparian plants are destroyed by rapid widening. Wood recruitment may increase if banks are forested, though retention depends on trees being large relative to increasing channel width.
	4-3. Renewed incision. Further head cutting within Stage 4 channel.	Increased range of floods retained in-bank continues to amplify flood pulse effects. Flood attenuation, groundwater recharge, base flow generation and hyporheic connectivity all remain dysfunctional.	Renewed incision maintains limited range of depth/velocity, combinations and so hydraulic diversity remains low. No new marginal deadwaters are created. Channel scour effectively eliminates functionality of substrate sorting and patchiness in providing habitat and ecosystem benefits.	Renewed scour removes embryonic bedforms and bars formed in Stage 4. Degree of disconnection of side channels, floodplain and wetlands due to channel incision increases. Any stored sediment or wood is flushed downstream. Continued bank retreat forms river cliffs that erode any remaining riparian fringe.	Aquatic, emergent, riparian and floodplain plant communities all depleted and dysfunctional. Low supply of leaf litter but wood recruitment maintained until proximal supply is exhausted. Retention depends on trees being large relative to increasing channel width.
	5. Aggrading and widening. Bed rising, banks stablising & berming.	No significant improvement in flood attenuation but flood pulse effects not quite as marked. Groundwater recharge remains dysfunctional, and base flows are still unreliable, but some hyporheic connectivity is recovered.	Aggradation renews depth/velocity variability that to improve hydraulic diversity. Small marginal deadwaters may develop, but these are not yet functional in providing habitat and ecosystem benefits. Bars and log jams begin to improve sediment sorting and patchiness.	Wetted area, shoreline length and complexity relative to flow all remain low. Aggradation generates some bedforms and bars but channel remains dysfunctional with regard to effective storage of sediment and wood. Bank stability improves marginally compared to Stage 4 allowing some recovery in riparian fringe. Floodplain connectivity begins to recover due to aggradation at bed and berm formation at banks.	Some return of aquatic plants. Bars and berms provide opportunities for emergent and riparian plants. Floodplain plant community remains isolated from channel physically and hydrologically. Widening may continue to recruit wood if there are proximal trees and supply of leaf litter may be renewed as well.
	6. Quasi-equilibrium. Regime channel and proto-floodplain re-established.	Remains disconnected from former floodplain, but increased boundary roughness and emergent riparian stands damp flood pulse effects and reintroduce some flood attenuation. Groundwater recharge and base flow functions begin to recover and hyporhesis continues to improve.	Developing regime channel interacts with proto-floodplain surfaces to dissipate energy and increase hydraulic diversity. Accumulation of sediment and colonization of bars and berms by emergent and riparian vegetation increases number and functionality of marginal deadwaters. Patches of contrasting substrate size and sorting develop accordingly.	Wetted area, shoreline length and complexity relative to flow all remain low. Bedforms and bars recover to pre-disturbance levels restoring some capacity to storage of sediment and wood. Bank stability continues to improve at expense of river cliffs, allowing further recovery in riparian fringe. Floodplain connectivity continues to recover and new side channels may be created, though wetlands remain disconnected.	Relatively stable channel margins and inset features provide sites for development of aquatic, emergent and riparian plant communities. Aggradation improves connectivity with and functionality of floodplain plants, maintaining wood recruitment and enhancing supply of leaf litter.
	7. Laterally active. Regime channel develops sinuous course.	Increases in flow resistance due to development of channel and inset floodplain roughness further damp flood pulse effects while returning groundwater recharge, base flow and hyporheic functionality back close to Stage 1 level.	Development of planform sinuosity and interaction with maturing floodplain enhance hydraulic diversity and make marginal deadwaters fully functional. Substrate sorting enhanced and patchiness becomes fully functional. Hydraulic and substrate attributes recover to Stage 1 levels.	Growth of sinuous channel increases wetted area, shoreline length and complexity. Bedforms and bars persist and new islands, confluences and diffluences develop, increasing capacity to storage of sediment and wood. Renewed bank erosion at bends broadens range of bank morphologies. Extent of new side channels increases with some wetlands created.	Extent of riparian and floodplain plant communities increases at expense of opportunities for emergent plants. Stabilisation of banks reduces wood recruitment but extension and maturing of riparian and floodplain communities maintain supply of leaf litter.
8. Anastomosing. Meta-stable anabranching network.		Hydrologic attributes and functions similar to Stage 0 but network inset within the channel created in Stage 4 as modified in Stage 7.	Hydraulic and substrate attributes and functions similar to Stage 0, but network inset within the channel created in Stage 4 as modified in Stage 7.	Morphological attributes and functions similar to Stage 0, but wetted area, shoreline length, and extent of floodplain and its features diminished because network is inset within the valley created in Stage 4.	Hydrological, hydraulic and morphological attributes and functions similar to those of Stage 0 allow vegetation attributes to recover to pre-disturbance levels.

Table 4- 2. Habitat and ecosystem benefits for each stage in the stream evolution model (Table 3 in Cluer and Thorne, 2013).

Table 3. Habitat and ecosystem benefits of each SEM Stage.

SEM		Habitat and Ecosystem Benefits			
		Habitat	Biota (see Thorpe et al. 2010)	Resilience and Persistence	Water Quality
0. Anastomosing. Dynamically meta-stable network of anabranching channels with vegetated islands supporting wet woodland or grassland.		Multiple channels, islands and broad floodplain provide access to rich palette of diverse habitats in close proximity and refugia across a wide range of flood events. High water table, deep pools and continuous hyporhesis provide drought refugia in the multiple channels. Channel margins evolve semi-continuously to expose tree roots.	Multiple, complex, dynamic channels that are connected to an extensive floodplain and which interact with groundwater and hyporhesis support large numbers of different species. This provides for the highest possible biodiversity (species richness and trophic diversity), proportion of native species, and 1^{st} and 2^{nd} order productivity.	Physical and vegetative attributes and functions stemming from their complexity, connectivity and diversity act to attenuate floods and sediment pulses, making habitat and biota persistent and highly resistant to natural and anthropogenic disturbances including flood, drought, and wild fire.	High capacity of multi-channel network to store sediment and cycle nutrients and other suspended solids produces exceptional water clarity. Dense, diverse proximal vegetation provides abundant shade which, together with efficient hyporhesis, is highly effective in ameliorating temperatures.
- Single Thread Channels -	**1.Sinuous, single-thread .** Stable and laterally active. Sediment sorting and transfer.	Palette of habitats somewhat reduced and range of flood refugia decreased though still high. Continued hyporhesis coupled with deeper scour pools in the single-thread channel provide excellent drought refugia. Reduction in length of shoreline decreases extent of exposed roots.	Single-thread channel connected to its floodplain. Channel still provides a good range of valuable habitat primarily at its margins, though reductions in morphological complexity and bankline length impact biodiversity and mean that biodiversity and productivity are moderate rather than high.	Sinuous channel form and close connectivity with floodplain, groundwater and hyporheic zones maintains high resilience to disturbance. Flood and drought resilience slightly reduced compared to that provided by the multi-channel system in Stage 0 due to some loss of effectiveness in attenuating floods.	Sediment storage and nutrient cycling capabilities slightly reduced but clarity still good in single channel/floodplain configuration. Temperature amelioration maintained due to effective shade and hyporhesis in channel/floodplain system.
	2. Channelized. Re-sectioned land drainage, flood control, or navigation channels.	Construction of trapezoidal cross-section, imposition of uniform morphology and isolation from floodplain destroys most habitat and disables functionality with respect to provision of flood and drought refugia. Exposed tree roots are removed during construction.	Disturbance due to channelisation is too rapid to allow many species (especially native species adapted to pre-disturbance conditions) time to adapt. As a result species richness and trophic diversity collapse, while 1^{st} and 2^{nd} order productivity declines markedly.	Simple geometry of constructed channel likely to change through aggradation, degradation or lateral migration unless bed level is fixed by structures and banks are revetted. Habitat and ecosystem benefits are vulnerable to disturbance and have negligible resilience to floods and droughts.	Wide range of flows concentrated into simplified channel without floodplain connection results in low water clarity and limited nutrient cycling. Poor temperature amelioration due to lack of riparian shading and ineffective hyporheic exchange.
	3. Degrading. Incising and abandoning its floodplain. Banks stable geotechnically.	Degradation destroys benthos, removes features that provide in-channel habitat and isolates channel from floodplain habitat. Channel scour and disconnection from floodplain mean that flood and drought refugia are destroyed or dis-functional. Tree roots exposed by bank scour.	Disturbance due to degradation is severe although some species have adapted to cope with this fluvial phenomenon, which occurs naturally as being generated anthropogenically. Species richness and trophic density still decrease with adverse impacts on 1^{st} and 2^{nd} order productivity.	Degradation makes remaining habitat and ecosystem benefits highly sensitive to disturbance in response to alterations to the flow and sediment regimes associated with, for example, climate or land-use changes. Resilience to flood and drought is negligible.	Functions responsible for water clarity and nutrient cycling further weakened due to bed scour, vegetation destruction loss and reduced groundwater interaction. Effective temperature amelioration impaired by lack of shade and poor hyporheic exchange.
	3s. Arrested degradation. Confined or canyon-type channels.	Loss of habitat and/or disabling of functions incurred in Stage 3 are perpetuated in the confined, incised channel that results from arrested development when a degrading channel encounters highly erosion-resistant materials.	Suitably adapted species will colonise the confined, incised channel provided it remains stable, increasing 1^{st} and 2^{nd} order productivity. Species richness, trophic density and proportion of native species will, however, remain low.	Erosion-resistant bed and bank materials stabilize the boundaries of a confined, incised channel this marginally reduces habitat and ecosystem sensitivity to disturbance and provides limited flood and drought resilience.	Functions responsible for water clarity and nutrient cycling remain ineffective. Temperature amelioration may recover if stable banks support riparian vegetation sufficiently tall to provide effective shade.
	4. Degradation and widening. Incising with unstable, retreating banks.	Continued degradation further damages benthos, bedform and bar features, preventing recover of in-channel habitats and increasing isolation from the floodplain. Bank instability destroys riparian habitat but does expose some tree roots.	Continued disturbance due to bed degradation and rapid bank retreat that destroy habitat result in low levels of biodiversity, and 1^{st} and 2^{nd} order productivity being sustained in Stage 4. The proportion of native biota cannot recover.	Degradation and rapid bank retreat exposes remaining habitat and ecosystem benefits to disturbance and negates their flood and drought resilience.	Physical attributes responsible for providing water clarity and nutrient cycling remain dysfunctional. Bank instability and rapid widening removes riparian shade, negating capability for temperature amelioration.
	4-3. Renewed incision. Further head cutting within Stage 4 channel.	Continued bed scour and bank retreat mean that no recovery in the range, proximity or connectivity of habitat is possible, though further enlargement of channel may improve its functionality in providing refugia during floods.	Cycles of incision and rapid bank retreat prevent recovery of habitat, perpetuating low levels of biodiversity, and leading to collapse of 1^{st} and 2^{nd} order productivity The proportion of native biota remains low.	Renewed incision and bank instability maintains the heightened sensitivity of residual habitat and ecosystem benefits to disturbance and prevents any recovery of flood and drought resilience.	Renewed incision, bank instability and widening reduce remaining capacity of the physical and vegetative attributes of the channel to provide habitat and ecosystem benefits with respect to water quality.
	5. Aggrading and widening. Bed rising, banks stablising & berming.	Channel remains impoverished with respect to provision of rich and diverse habitat dysfunctional with respect to drought refuge. Creation of bedforms and bars at the aggrading bed may provide limited refuge during floods.	Reinstatement of some benthic sediments and in-channel features is reflected in some recovery in 1^{st} and 2^{nd} order productivity. However, at this stage biodiversity and the proportion of native biota have yet to respond.	Return of benthic sediments and in-channel features allow channel to absorb at least small disturbances without destroying habitat. Enlarged channel dimensions and conveyance tend to increase resilience to floods though not droughts.	Re-creation of bedforms, bars and berms together with return of aquatic, emergent and riparian vegetation re-activate sediment storage and nutrient cycling functions, though water clarity and capacity for temperature amelioration remain limited.
	6. Quasi-equilibrium. Regime channel and proto-floodplain re-established.	Some improvement in palette of accessible habitat, matched by provision of limited flood refuge and exposed roots from recovery of some in-channel features and vegetation. Reconnection of channel to groundwater and hyporheic zones result in some drought refugia.	Quasi-equilibrium, coupled with recovery of floodplain and hyporheic connectivity supports limited improvements in species richness and trophic diversity and allows some native biota to return. 1^{st} and 2^{nd} order productivity continues to increase as a result.	Quasi-equilibrium channel increasingly able to absorb moderate disturbances to flow and sediment regimes without loss of habitat and ecosystem benefits. In-channel features, vegetation, and floodplain connectivity and hyporhesis afford moderate flood and drought resilience.	Increases in the extent of the inset floodplain and riparian zones, vegetation re-growth and re-establishment of hyporheic connectivity provide moderate functionality for clarity and temperature amelioration, though nutrient cycling remains weak.
	7. Laterally active. Regime channel develops sinuous course.	Further improvement in range, quality and accessibility of habitat, coupled with improved functionality in terms of flood and drought refugia. Habitat benefits similar to Stage 1 channel, though habitat palette somewhat smaller.	The wider range of habitat in the increasingly diverse channel supports further improvement in biodiversity, while native species colonise and use the sinuous channel and developing floodplain. Productivity remains moderate.	Disturbances to channel increasingly ameliorated by flow and sediment storage on developing floodplain, though sensitivity remains higher than in Stage 1 due to its smaller extent. Flood and drought resilience similarly limited.	Plant succession and maturing floodplain and riparian zones increase efficiency of nutrient cycling and provision of shade. Water clarity remains moderate but temperature amelioration further improved.

4.1.b. Stream Type or Classification

Classifying streams in categories by characteristics can help to discuss and describe the streams. Rosgen's (1996) Classification of Natural Rivers is a system to describe the current and potential future conditions of a stream channel. The broad level (Level I) classification describes the streams as stream types: Aa+, A, B, C, D, DA, E, F or G based on the slope, sinuosity, width to depth ratio, and entrenchment ratio (width of the flood prone area at the elevation twice the maximum bankfull depth divided by the bankfull width) (Table 4-3).

Table 4- 3. General stream type descriptions for Level 1 Rosgen stream classification (Table 4-1 in Rosgen, 1996).

Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landform/ Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0 to 1.1	>.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	.04 to .10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>1.2	.02 to .039	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate w/scour pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains.	>2.2	>12	>1.2	<.02	Broad valleys w/terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	>40	n/a	<.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment, w/abundance of sediment supply. Convergence/divergence bed features, aggradational processes, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	>2.2	Highly variable	Highly variable	<.005	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.2	<.02	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	.02 to .039	Gullies, step/pool morphology w/moderate slopes and low width/depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

In Rosgen's (1996) classification system, Level II classification allows more finely resolved criteria to address questions of sediment supply, stream sensitivity to disturbance, recovery potential, channel response to changes in flow regime, and fish habitat potential. Level II classification includes the Level I classification as well as the dominant substrate type. Figure 4-4 shows the primary delineative criteria for Rosgen (1996) Level II stream types and Figure 4-5 is the key to the Rosgen Classification of Natural Rivers.

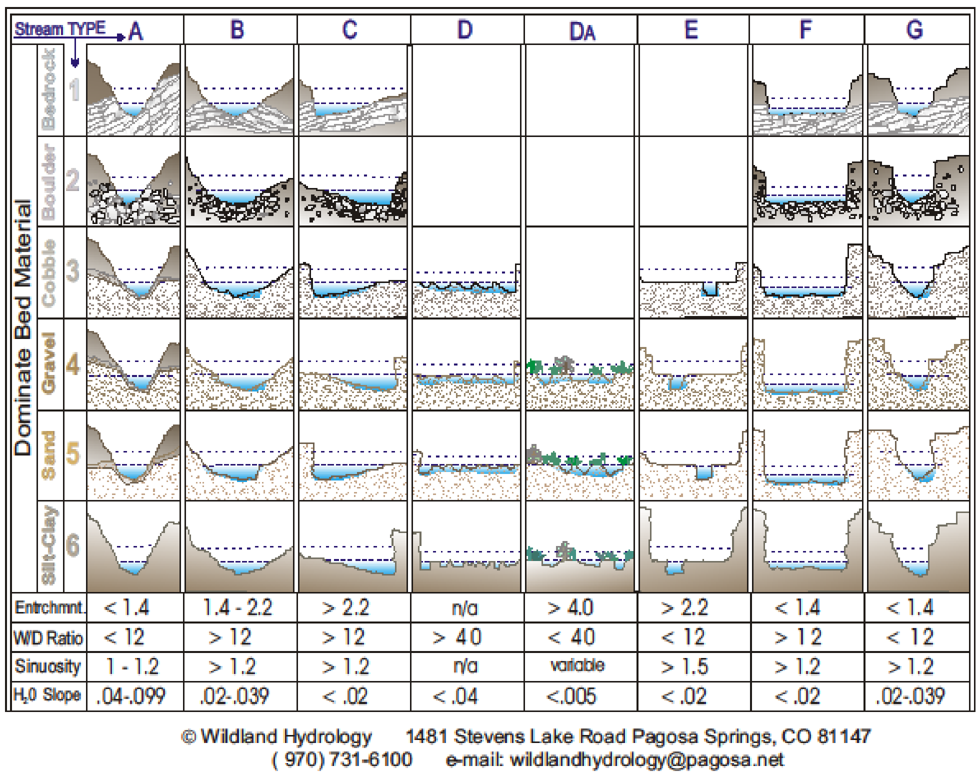


Figure 4- 4. Primary delineative criteria for the major Rosgen stream types (Figure 5-2 in Rosgen, 1996).

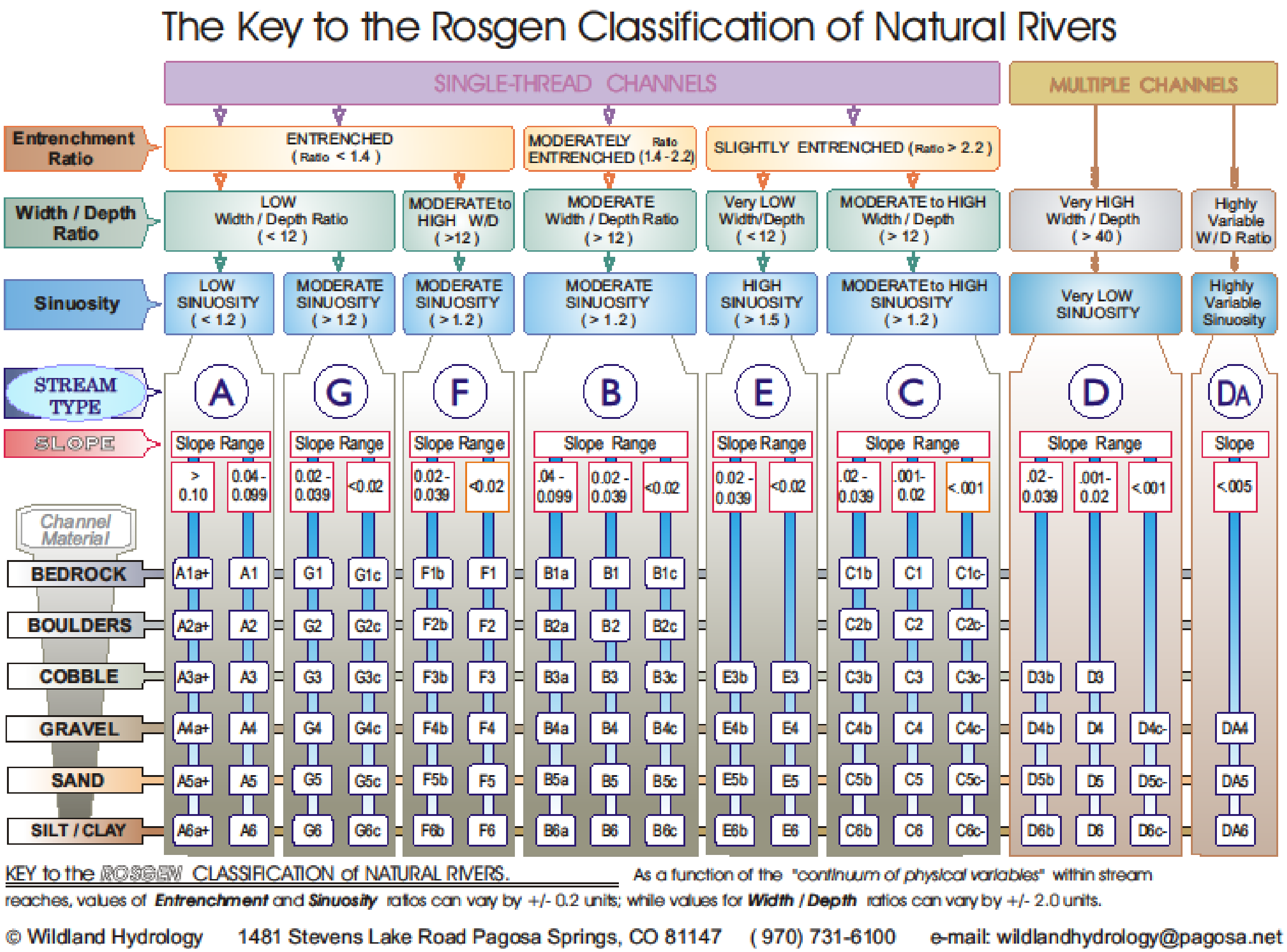


Figure 4- 5. Key to the Rosgen Classification of Natural Rivers (Figure 5-3 in Rosgen, 1996).

4.2 South Fork Coquille River Reaches

To better describe the South Fork Coquille River, it is broken into different reaches, based on geomorphic characteristics that would result in different stages of stream evolution and stream types. Inter-Fluve, Inc. (2013) separated the South Fork Coquille River into twelve reaches (see Table 1-1 and Figure 1-10). Comparisons to Clearwater Bio-Studies (2003) and the USGS study (Jones et al., 2012) reaches can be found in that table as well. Inter-Fluve, Inc. (2013) included air photos of each reach. Each one of these is found in Appendix E.

4.3 South Fork Coquille River Stream Features: Morphological Characteristics, Channel Evolution Stage, Target Streamtype, and Channel Stability

Since the reaches are designated by changes in morphological characteristics, each of the twelve reaches in Inter-Fluve, Inc. (2013) can be described by these features. The morphological characteristics of the South Fork Coquille River are shown in Table 4-4. The stage of channel evolution, target streamtype, and channel stability of each reach along the South Fork Coquille River is shown in Table 4-5.

Table 4- 4. South Fork Coquille (SFC) River morphological characteristics. Reach numbers in this Action Plan correspond with reach numbers in Inter-Fluve, Inc. (2013)[1].

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Dimension	Pattern		Profile	Floodplain Accessibility	Channel Description
		Width/Depth Ratio	Sinuosity	Meander Width Ratio	Slope ft./ft.	Recurrence Interval	
RM 0-4.8 Interfluve (I) Reach 1 CBS[2]-SFC-1, Jones et al. (2012) (USGS Report) - Myrtle Point Reach	Between confluence of North and Middle Forks. Myrtle Point is in this reach.	Status: 9.9[3] Target: >12	Status: 1.19 Target: >1.4	Status: 6.7 Target: 11.4 Minimum: 4	Status: 0.001 Target: <0.001-.02	Status: 2 to 5 Target: 2	Unconfined alluvial reach flowing through wide valley 1475-4630 ft. (Jones et al., 2012); Tidally influenced to RM 3 (CBS, 2003 and Jones et al., 2012). There are low amounts stored and potential LW. Bankfull discharge estimated at 37,400 cfs, being nearly doubled by the addition of the Middle Fork Coquille (246 to 593 mi^2).
RM 4.8-10.2 I-2 CBS-SFC-2, Jones et al. (2012) - Broadbent Reach (partial)	From upstream of Middle Fork to the West Side Road bridge in Broadbent.	Status: 10.5 Target: >12	Status: 2.14 Target: >1.4	Status: 7.5 Target: 11.4 Minimum: 4	Status: 0.0024 Target: <0.001-.02	Status: 5 Target: 2-5	Unconfined alluvial segments inset in a high bank terrace that flow through wide floodplain, straighter segments with alternating lateral bars, and moderately braided segments. LW is limited.

[1] A crosswalk of reach numbers can be found in Table 1-3.
[2] CBS = Clearwater BioStudies, Inc.
[3] Red lettering indicates that the reach average is below the target condition.

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Dimension	Pattern		Profile	Floodplain Accessibility	Channel Description
RM 10.2-15.3 I-3 CBS-SFC-3, Jones et al. (2012) - Broadbent Reach (partial)	From the West Side Road Bridge to just upstream of Dement Creek	Status: 15.2 Target: >12	Status: 1.55 Target: >1.4	Status: 5.3 Target: 11.4 Minimum: 4	Status: 0.0024 Target: <0.001-.02	Status: 5->100 Target: 2-5 to >100 depending upon resistant hillslope control vs. alluvial terraces	Transition area between broad alluvial valleys and tightly confined river. Where not hillslope constrained, unconfined alluvial segments inset in a high bank terrace that flow through wide floodplain, straighter segments with alternating lateral bars, and moderately braided segments. LW is limited.
RM 15.3-19.6 I-4 CBS-SFC-4 & 0.4 miles of SFC-5, Jones et al. (2012) - Broadbent Reach (partial)	Just upstream of Dement Creek to just upstream of Gaylord Creek.	Status: 13.6 Target: >12	Status: 1.15 Target: >1.4	Status: 5.3 Target: 5.3 Minimum: 2	Status: 0.0038 Target: <0.02	Status: 100 Target: 2-5 to 100 depending upon resistant hillslope control vs. alluvial terraces	Fully confined bordered by hillslopes, alluvial fan, and terraces. Terraces are more extensive from RM 17.8-19.1. Some LW present from MP15.3-17.0 but much more is needed upstream.
RM 19.6-23.5 I-5 CBS-SFC-5, Jones et al. (2012) - Broadbent Reach	Just upstream of Gaylord Creek to near the confluence of Rowland Creek.	Status: 13.3 Target: >12	Status: 1.33 Target: >1.4	Status: 10.3 Target: 11.4 Minimum: 4	Status: 0.0021 Target: <0.02	Status: 2 to 25 Target: 2 to 10 depending upon resistant hillslope control vs. more erosive terraces	Valley width increases relative to up and downstream reaches; the channel has wide meanders near the downstream end of the reach. LW is limited

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Dimension	Pattern		Profile	Floodplain Accessibility	Channel Description
RM 23.5-27.6 I-6 CBS-SFC-6 more or less, Jones et al. (2012) - Powers Reach (partial)	From the confluence of Rowland Creek to the bridge crossing just downstream of Powers.	Status: 10.8 Target: >12	Status: 1.01 Target: >1.4	Status: 10.2 Target: 5.3 Minimum: 2	Status: 0.0025 Target: <0.001-.02	Status: Entrenched , no floodplains	The reach is very confined by steep hillslopes and high terrace surfaces on both sides. At the downstream end of the reach, a bedrock type transition from highly erodible to rock that is more resistant. Channel slope steeper than downstream reaches with gravel/cobble substrate. Width/depth ratio and sinuosity, while slightly below target, are considered met because of lateral stability from resistant hillslopes. LW is limited.
RM 27.6-30.6 I-7 CBS-SFC-7 (approximately), Jones et al. (2012) - Powers Reach (partial)	From the bridge crossing just downstream of Powers and the confluence of Woodward Creek to just downstream of the confluence of Mill Creek	Status: 15.5 Target: >12	Status: 1.26 Target: >1.4	Status: 10.8 Target: 11.4 Minimum: 4	Status: 0.0025 Target: 0.001-0.02	Status: 2-10 Target: 2-5	The valley width expands significantly at a transition between more resistant and highly erodible rock (which is a pattern that persists upstream). There is a narrow inset floodplain between high terrace surfaces on both sides of the river. LW is limited (CIT[4], 2005 and USDA USFS, 2007).

[4] CIT = Coquille Indian Tribe

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Dimension	Pattern		Profile	Floodplain Accessibility	Channel Description
RM 30.6-35.1 I-8 CBS-SFC-8 (approximately), Jones et al. (2012) - Powers Reach (partial)	From just downstream of the confluence of Mill Creek to the confluence of Upper Land Creek (near the boundary of the Rogue River-Siskiyou National Forest).	Status: No Data Target: >12	Status: 1.31 Target: >1.2	Status: No Data Target: 3.7 Minimum: 2	Status: 0.003 Target: <0.02	Status: Moderately entrenched, limited floodplains, controlled by resistant hillslopes and bedrock.	Average valley width decreases somewhat relative to Reach 7, with the channel alternating between valley walls with alluvial surfaces formed on the inside of large meanders. Alluvial surfaces are Pleistocene terraces that confine the channel and not part of the historic floodplain. LW is limited.
RM 35.1-38.2 I-9	From the confluence of Upper Land Creek (near boundary of the Rogue River-Siskiyou National Forest) to the confluence of Sand Rock Creek where slope increases abruptly.	Status: No Data Target: >12	Status: No Data Target: >1.2	Status: No Data Target: 3.7 Minimum: 2	Status: 0.013 Target: <0.02	Status: Moderately entrenched, no floodplains	Canyon reach with relatively narrow valley width. Average gradient of 1.3%, which is much steeper than downstream reaches. Channel confined between hillslopes that are nearly vertical in many locations. Channel steep riffles and pools typically. LW is limited (USDA USFS, 2007).
RM 38.2-52.6 I-10	From the confluence of Sand Rock Creek to the confluence of Panther Creek (includes Coquille Falls).	Status: No Data Target: <12	Status: No Data Target:<1.2	Status: No Data Target: 1.5 Minimum: 1	Status: 0.015-.08 Target: <.02-.099	Status: Entrenched , no floodplains	Continuous canyons reach through cliff-forming, erosion-resistant rock. Channel gradient steep (1-2%) - as high as 8% upstream near Coquille Falls. LW is limited but not deficient, due to the steep river slope and corresponding high-energy environment (CIT, 2005 and USDA USFS, 2007).

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Dimension	Pattern		Profile	Floodplain Accessibility	Channel Description
RM 52.6-55.3 I-11	From the confluence of Panther Creek to the confluence of Buck Creek.	Status: No Data Target: <12	Status: No Data Target:<1.2	Status: No Data Target: 1.5 Minimum: 1	Status: 0.006 Target: <.02-.099	Status: Entrenched , partial floodplains	A tightly confined canyon reach with less gradient than in Reach 10. Hillslopes not as steep and valley width increases slightly which allows for narrow floodplain surfaces in places. LW is limited (CIT, 2005 and USDA USFS, 2007).
RM 55.3-60.4 I-12	From the confluence of Buck Creek to just upstream of Foggy Creek and the headwaters of the South Fork Coquille River.	Status: No Data Target: <12	Status: No Data Target:<1.2	Status: No Data Target: 1.5 Minimum: 1	Status: 0.01+ Target: <.02-.099	Status: Moderately entrenched , partial floodplains	The geology is slightly more erodible than Reach 11 resulting in gentler hillslopes and slightly wider valleys. However, the river remains naturally confined with narrow floodplain surfaces. The widest valley is at the downstream end at Ash Swamp which has alluvial deposits. Lower gradient areas have slow glides and pools and low gradient riffles; whereas steeper portions have higher energy riffles (USDA USFS, 2007). LW is limited (CIT, 2005 and USDA USFS, 2007).

Table 4- 5. South Fork Coquille (SFC) River channel evolution, target streamtype and channel stability. Reach numbers in this Action Plan correspond with reach numbers in Inter-Fluve, Inc. (2013)[5].

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Channel Evolution & Target Streamtype	Channel Stability		
		Simon & Rinaldi (2006), Rosgen (1996)	Near Bank Stress, Erodibility	Bed/Sediment Storage	Summary
RM 0-4.8 Interfluve (I) Reach 1 CBS[6]-SFC-1, Jones et al. (2012) - Myrtle Point Reach	Between confluence of North and Middle Forks. Myrtle Point is in this reach.	Stage IV Degradation and Widening Rosgen: C4c	Status: High (CBS, 2003)	Status: Reduction of instream bars (Jones et al., 2012). LW could help sediment storage; bars have decreased but not as much as in other reaches.	Incised, over-widened channel with actively eroding banks that is disconnected from floodplain (F&W[7], 1995; CBS, 2003; and Jones et al., 2012), reduced bank and riparian vegetation and low amounts of in-channel LW prevent stabilization and detainment of gravels; dredging and log driving locally increased slope (F&W, 1995); current analysis shows channel degradation but to a lesser degree than upstream and a reduction of instream bars (Jones et al., 2012).
RM 4.8-10.2 I-2 CBS-SFC-2, Jones et al. (2012) - Broadbent Reach (partial)	From upstream of Middle Fork to the West Side Road bridge in Broadbent.	Stage IV Degradation and Widening Rosgen: C4	Status: Very High (CBS, 2003)	Status: Reduction of instream bars (Jones et al., 2012)	High; vertical banks apx. 25 ft. tall in some places (F&W, 1995) to 30 ft. (BLM, LIDAR); thalwag incision 2 feet in some locations; ongoing bank erosion and widening; 9500 ft. of actively eroding banks some of which severe (CBS, 2003, BEA&PA[8], 2010); gravel bar area and bars have decreased more here and in Reach 3 than in other reaches (Jones et al., 2012).

[5] A crosswalk of reach numbers can be found in Table 1-3.
[6] CBS = Clearwater BioStudies, Inc.
[7] F&W = Florsheim and Williams
[8] BEA&PA = BioEngineering Associates, Inc. and Parry Associates

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Channel Evolution & Target Streamtype	Channel Stability		
		Simon & Rinaldi (2006), Rosgen (1996)	Near Bank Stress, Erodibility	Bed/Sediment Storage	Summary
RM 10.2-15.3 I-3 CBS-SFC-3, Jones et al. (2012) - Broadbent Reach (partial)	From the West Side Road Bridge to just upstream of Dement Creek	Stage IV Degradation and Widening Rosgen: C4	Status: Very High (CBS, 2003)	Supply limited; bar area and number of bars has decreased (Jones et al., 2012).	Gravel limited as evidenced by decreased numbers of bars over time; 7700 feet of actively eroding banks (BEA&PA, 2012).
RM 15.3-19.6 I-4 CBS-SFC-4 & 0.4 miles of SFC-5, Jones et al. (2012) - Broadbent Reach (partial)	Just upstream of Dement Creek to just upstream of Gaylord Creek.	Stage IV Degradation and Widening, except where hillslope constrained Rosgen: F4	Status: Moderate (CBS, 2003)	Some bars present but overall supply limited.	MP15.3-17.0 - few symptoms of channel degradation; MP 17.0-19.6 high unvegetated eroding banks; both vertical and lateral instability; within Broadbent reach that has undergone the greatest degree of channel widening in the area; Gaylord bridge marks upstream boundary of the reach that experienced 6 feet of downcutting from 1994-2008.
RM 19.6-23.5 I-5 CBS-SFC-5, Jones et al. (2012) - Broadbent Reach	Just upstream of Gaylord Creek to near the confluence of Rowland Creek.	Stage IV Degradation and Widening, except where hillslope constrained Rosgen: C3/C4	Status: Moderate (CBS, 2003)	Three gravel mining sites within the reach. Cumulative gravel removal in the Broadbent reach of the Jones et al. (2012) study was around 43% of all material deposited.	Number of bars and size of bars has declined, but still present throughout the reach; 5627 feet of actively eroding banks in the reach (BEA&PA, 2012); many eroding banks are in areas that would be expected to have tall exposed banks and do not represent channel response to disturbance; channel eroding laterally into hillslope and terrace deposits may increase bank stability and provide better opportunities for margin and in-channel habitat enhancement.

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Channel Evolution & Target Streamtype	Channel Stability		
		Simon & Rinaldi (2006), Rosgen (1996)	Near Bank Stress, Erodibility	Bed/Sediment Storage	Summary
RM 23.5-27.6 I-6 CBS-SFC-6 more or less, Jones et al. (2012) - Powers Reach (partial)	From the confluence of Rowland Creek to the bridge crossing just downstream of Powers.	Stage III Degradation , except where hillslope constrained Rosgen: F3/F4	Status: Moderate-Low (CBS, 2003)	There has been a decline in bar area and number since 1939 (Jones et al., 2012).	Channel stability relatively high. Centerline position stable between 1939 and 2011 (Jones et al., 2012). Bed material is gravel and cobble. The river flows against hillslopes and terraces, providing lateral stability (CBS, 2003).
RM 27.6-30.6 I-7 CBS-SFC-7 more or less, Jones et al. (2012) - Powers Reach (partial)	From the bridge crossing just downstream of Powers and the confluence of Woodward Creek to just downstream of the confluence of Mill Creek	Stage III Degradation Rosgen: C3/C4	Status: Moderate (CBS, 2003)	Gravel deposits are mainly composed of narrow and elongated point bars. There has been a decline in both bar area and number of bars since 1939 (Jones et al., 2012).	Overall channel stability is relatively high. Banks are geotechnically stable with moderate near bank shear stress and low bank erodibility (CBS, 2003) A portion has had about 20 feet of channel widening since 1939 and overall degradation due to channel incision (Jones et al., 2012).
RM 30.6-35.1 I-8 CBS-SFC-8 more or less, Jones et al. (2012) - Powers Reach (partial)	From just downstream of the confluence of Mill Creek to the confluence of Upper Land Creek (near the boundary of the Rogue River-Siskiyou National Forest).	Stage III Degradation Rosgen: B3c/B4c	Status: Moderate-Low	Gravel deposits are mainly mid channel bars. Tributaries in this reach drain steep drainages with active logging, thin soils and erodible bedrock creating a likelihood of sediment contribution.	Channel stability generally high due to lateral confinement and near surface bedrock. At the Johnson Road bridge there was a decrease in thalwag elevation from 1994-2008 (Jones et al., 2012).

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Channel Evolution & Target Streamtype	Channel Stability		
		Simon & Rinaldi (2006), Rosgen (1996)	Near Bank Stress, Erodibility	Bed/Sediment Storage	Summary
RM 35.1-38.2 I-9	From the confluence of Upper Land Creek (near boundary of the Rogue River-Siskiyou National Forest) to the confluence of Sand Rock Creek where slope increases abruptly.	Stage II Constructed Rosgen: B3c/B4c	Status: Low	Tributaries drain steep watersheds with active logging, thin soils, and erodible underlying bedrock, which adds to sediment contribution.	Essentially stable in all dimensions, though deposition of fine sediment from logging affects pool quality and depth.
RM 38.2-52.6 I-10	From the confluence of Sand Rock Creek to the confluence of Panther Creek.	Stage II Constructed Rosgen: B/A	Status: Low	Regeneration harvest adjacent to channel increases risk of sedimentation through erosion and mass wasting.	Very high stability since bedrock cliffs and hillslopes create immobile channel margins on both sides of the river. Vertical stability supported by bed material and extreme incision is unlikely in this reach.
RM 52.6-55.3 I-11	From the confluence of Panther Creek to the confluence of Buck Creek.	Stage II Constructed Rosgen: B/A	Status: Low	Logging has increased fine sediment production.	Likely stable. The natural confinement and near surface bedrock increase lateral stability. Vertical stability held by large bed material and near surface bedrock (though aggradation is a possibility) With clearcut logging taking place on steep hillslopes adjacent to the channel, there is increased risk of hillslope erosion and mass wasting that could locally destabilize the channel.
RM 55.3-60.4 I-12	From the confluence of Buck Creek to just upstream of Foggy Creek and the headwaters of the South Fork Coquille River.	Stage II Constructed Rosgen: B/A	Status: Low	Logging has increased fine sediment production	Vertical and lateral channel stability is relatively high in this reach, providing for resiliency to disturbance.

4.4 South Fork Coquille River Change Detection: Channel Centerline, Width and Bar Measurements

The South Fork Coquille River is continually changing. The USGS gravel transport study (Jones et al., 2012) concentrated on the lower 60% of the river, and used change detection methods by the sequential time analysis of aerial photographs from 1939 to 2009 to observe these changes. Changes in channel centerline, wetted width, and the area and distribution of bars were observed. All photography was flown during low flow periods with the exception of the 1967 set. New aerial photography became available in 2011, after the analysis was completed for the USGS study (Jones et al., 2012) and the new aerial photography was analyzed by Inter-Fluve., Inc. (2013) in a manner similar to the USGS study for a direct comparison.

Results are discussed in terms of the USGS (Jones et al., 2012) reach names: the Myrtle Point reach (RM 0-4.8, Inter-Fluve, Inc. Reach 1), the Broadbent reach (RM 4.8-23.5, Inter-Fluve, Inc. Reaches 2-5), and the Powers reach (RM 23.5-35.1, Inter-Fluve, Inc. Reaches 5-8). The Powers and Broadbent reaches are predominantly alluvial with short constricted sections formed by Pleistocene terraces and bedrock. The Myrtle Point reach is tidally influenced in addition to being an alluvial reach. (Inter-Fluve, Inc. 2013)

Table 4-6 shows the results of USGS (Jones et al. 2012) channel centerline and width measurements. South Fork Coquille channel centerline length was the most stable long-term characteristic. All reaches saw a 1% change with the Myrtle Point reach experiencing an increase in length and the Broadbent and Powers reaches experiencing decreases. The stability of centerline length implies that there were little net increases, or decreases in sinuosity. (Inter-Fluve, Inc. 2013)

All reaches experienced substantial channel widening over all time periods. The greatest long-term percent changes were in the alluvial reaches (Powers and Broadbent) where percent channel widening was 29% and 43% respectively. This equates to 20 and 27 feet of widening on average respectively over the long-term at a rate of 0.3 and 0.4 feet per year. Long-term widening in the Myrtle Point reach occurred at a smaller magnitude with 13 feet, or 16% wider channel. In all reaches, recent widening since 2009 occurred at an increased rate compared to the long-term previous time period (1939-2009). The wetted width of the Powers reach increased at an annual rate of 8 feet/year while the Myrtle Point reach widened at a rate of 2 feet/year. (Inter-Fluve, Inc., 2013)

Permitted gravel removal may be having an impact on channel morphology including widening when bar scalping exceeds gravel replenishment in any year. The rate of channel widening should be carefully monitored to see if there is a correlation with gravel removal or some other responsible factors can be identified. The comparison of any short time period is likely to yield rates and magnitudes of change different than the long-term average (Inter-Fluve, Inc., 2013). It is the long-term trend that should be weighted more heavily in restoration planning (Inter-Fluve, Inc., 2013). Considering the long-term trend we see a channel that, despite limited lateral migration of the channel centerline, is adjusting laterally (0.2 to 0.4 feet/year on average) through constant widening of the wetted channel (Inter-Fluve, Inc., 2013).

Table 4- 6. Results of the USGS (Jones et al., 2012) repeat channel centerline and wetted channel width measurements with a 2011 updated data set (Table 1 in Inter-Fluve, Inc., 2013).

Channel Centerline Length (ft)														
Reach	1939	1967	2005	2009	2011	1939-2009 % Change	1939-2011 % Change	2009-2011 % Change	1939-2009 Net Change (ft)	1939-2011 Net Change (ft)	2009-2011 Net Change (ft)	1939-2009 Rate (ft/yr)	1939-2011 Rate (ft/yr)	2009-2011 Rate (ft/yr)
Powers	36,670	36,211	36,670	36,638	36,447	-0.1	-1	-1	-33	-223	-190	-0.5	-3.1	-95
Broadbent	100,827	98,564	100,270	100,729	100,211	-0.1	-1	-1	-98	-616	-518	-1.4	-8.6	-259
Myrtle Point	24,862	24,698	25,059	25,190	25,135	1	1	0	328	273	-55	4.7	3.8	-28

Average Wetted Channel Width (ft)														
Reach	1939	1967	2005	2009	2011	1939-2009 % Change	1939-2011 % Change	2009-2011 % Change	1939-2009 Net Change (ft)	1939-2011 Net Change (ft)	2009-2011 Net Change (ft)	1939-2009 Rate (ft/yr)	1939-2011 Rate (ft/yr)	2009-2011 Rate (ft/yr)
Powers	68.9	118.1	78.7	72.2	88.9	5	29	23	3	20	17	0.0	0.3	8
Broadbent	62.3	95.1	85.3	78.7	88.9	26	43	13	16	27	10	0.2	0.4	5
Myrtle Point	82.0	101.7	95.1	91.8	95.4	12	16	4	10	13	4	0.1	0.2	2

Characteristics of bar features (point bars, lateral bars, mid-channel bars, etc.) were the second part of the study that was carried out by the USGS (Jones et al., 2012) and updated by Inter-Fluve Inc. (2013) as shown in Table 4-7. The update to bar feature analysis (2009-2011) shows some substantial changes in trends for several characteristics in most reaches, suggesting that recent changes have been of large magnitude and not in line with the long-term trends (Inter-Fluve, Inc., 2013).

Change in total bar area was one characteristic whose long-term trend remained unchanged by updated analysis. In the Powers and Broadbent reaches there were large decreases in total gravel bar area and average gravel bar area for all analyzed time periods (45% and 56% decrease between 1939 and 2011 respectively). In the Myrtle Point reach, the long-term trend remained slightly positive, with a 1% increase in bar area. However, prior to the update the trend had been strongly positive, but large decreases in bar area over the recent time period drove the average down substantially. Recent rates of bar area decrease in the Powers and Broadbent reaches were also much greater than the long-term average. (Inter-Fluve, Inc., 2013)

The updated analysis of total number of bars changed the long-term trend from increasing bars to decreasing bars in both the Broadbent (from a 10% increase to a 14% decrease) and Myrtle Point (from a 32% increase to a 27% decrease) reaches. Again, this is due to substantial recent change, namely large decreases in the total number of bars in the recent time period. In the Powers reach, the trend of decreasing number of bars was maintained at about 25% through the updated analysis. (Inter-Fluve, Inc., 2013)

Similar alterations to trends occurred through the update of average bar area. Trends in average bar area depend on the interplay between total bar area and the total number of bars. In the Myrtle Point reach, where the total bar area remained relatively constant but the total number of bars decreased recently, the updated long-term average bar area went from a 3% decrease in average bar area to a 39% increase. In the Powers reach, long-term reductions in average bar area became greater (from 1% to 26% decrease) through updated analysis. Trends in the Broadbent reach remained relatively constant. (Inter-Fluve, Inc., 2013)

Recent large changes in bar characteristics similarly affected unit bar area, which is calculated as the total bar area per foot of channel centerline. Channel centerline lengths were fairly constant for all reaches. However, recent substantial changes in total bar area resulted in changes to long-term trends in unit bar area changed through the updated analysis. The Myrtle Point reach again showed a near reversal in its trend of increasing unit bar area going from a 26% increase to a slight decrease (0.3%) in unit bar area through the updated analysis. In the Powers reach, updated analysis changed a 24% decrease in unit bar area to a 44% decrease, maintaining and increasing the previous trend. The Broadbent reach was more consistent through the updated analysis (45% and 55% decreases in unit bar area between 1939-2009 and 1939-2011 respectively). (Inter-Fluve, Inc., 2013)

Recent trends suggest that permitted gravel removal may be having an impact on channel morphology including channel widening and decreasing bar area and numbers of bars. Gravel bar scalping could be exceeding gravel replenishment especially considering recent annual runoff has been without notable high flows that carry the majority of the annual sediment yield. Unless the rate of bar removal is slowed from recent accelerated rates, ongoing out of trend channel widening and increased bank undercutting can be expected to occur.

Monitoring is key to determine if there is a correlation with gravel removal or some other responsible factors can be identified. An approach similar to the U.S. Army Corps of Engineers (ACOE) general permit (NWP-2008-00071) (U.S. ACOE, 2011) that authorizes commercial gravel mining activities within the Chetco River, Curry County, Oregon could be developed for the South Fork Coquille. The permit (U.S. ACOE, 2011) describes bar site locations by river mile and annual reserve volumes of gravel (cubic yards) that must be maintained before activity. If the influx is sufficient to exceed the annual reserve volume requirement, then gravel harvesting can occur, otherwise the aggregate must be allowed to accumulate. In this way, substantial bar destruction is avoided and unintended consequences of channel widening and undermining of stream banks. The ACOE permit (U.S. ACOE, 2011) also describes gravel extraction locations along a bar, bar retention criteria and an allowance for habitat improvement.

Table 4- 7. Results of USGS (Jones et al., 2012) repeat bar characteristic measurements with a 2011 updated data set (Table 2 in Inter-Fluve, Inc., 2013).

	Bar Area (ft²)										
Reach	1939	1967	2005	2009	2011	1939-2009 % Change	1939-2011 % Change	2009-2011 % Change	1939-2009 Rate (ft/yr)	1939-2011 Rate (ft/yr)	2009-2011 Rate (ft/yr)
Powers	1,986,726	775,150	1,398,908	1,512,103	1,100,155	-24	-45	-27	-6,780	-12,313	-205,974
Broadbent	6,799,029	3,528,634	3,550,477	3,765,677	3,015,339	-45	-56	-20	-43,334	-52,551	-375,169
Myrtle Point	534,880	280,728	593,952	682,830	539,060	28	1	-21	2,114	58	-71,885
	Total Bars										
Reach	1939	1967	2005	2009	2011	1939-2009 % Change	1939-2011 % Change	2009-2011 % Change	1939-2009 Rate (ft/yr)	1939-2011 Rate (ft/yr)	2009-2011 Rate (ft/yr)
Powers	64	49	55	49	48	-23	-25	-2	-0.2	-0.2	-0.5
Broadbent	122	77	128	134	105	10	-14	-22	0.2	-0.2	-14.5
Myrtle Point	22	15	20	29	16	32	-27	-45	0.1	-0.1	-6.5
	Average Bar Area (ft²)										
Reach	1939	1967	2005	2009	2011	1939-2009 % Change	1939-2011 % Change	2009-2011 % Change	1939-2009 Rate (ft/yr)	1939-2011 Rate (ft/yr)	2009-2011 Rate (ft/yr)
Powers	31,096	15,817	25,394	30,881	22,920	-1	-26	-26	-3	-114	-3,981
Broadbent	55,737	45,838	27,761	28,084	28,718	-50	-48	2	-395	-375	317
Myrtle Point	24,318	18,722	29,698	23,564	33,691	-3	39	43	-11	130	5,063
	Unit Bar Area (ft²/ft)										
Reach	1939	1967	2005	2009	2011	1939-2009 % Change	1939-2011 % Change	2009-2011 % Change	1939-2009 Rate (ft/yr)	1939-2011 Rate (ft/yr)	2009-2011 Rate (ft/yr)
Powers	54	21	38	41	30	-24	-44	-27	-0.2	-0.3	-5.5
Broadbent	67	36	35	37	30	-45	-55	-20	-0.4	-0.5	-3.6
Myrtle Point	22	11	24	27	21	26	-0.3	-21	0.1	0.0	-2.8

Chapter 5: Restoration Approach

5.1 Ecological Factors to Consider in Restoration Approach

The historic and current condition of the streams and its tributaries paints a picture of the current condition, which allows for the development of restoration strategies. Restoration strategies built from this informed perspective stand to be more successful in planning, implementation, and longevity (Inter-Fluve, Inc., 2013). Because disturbance and degradation is widespread in the river system, several reaches share common restoration limitations and potential; several common restoration strategies are developed at multiple scales in order to address systemic disturbances that are limiting recovery of the system (Inter-Fluve, Inc., 2013). More discussion on the methodologies for restoration can be found in Chapter 6.

5.1.a. Overview of Watershed, Reach, and Site Scale Restoration Strategies

5.1.a.i. Watershed Scale Restoration Strategy (Inter-Fluve, Inc., 2013)

General restoration guidelines that apply across reach boundaries can be considered watershed scale restoration approaches. Restoration at the watershed scale focuses on addressing root causes that manifest at the reach and site scale throughout the study area. Watershed scale restoration is normally prioritized from upstream to downstream over long time periods (several years to decades). For example, re-vegetating clearcut hillslopes in headwaters tributaries would generally take priority of the same activity near the downstream end of the watershed because the result of restoring the headwaters will have an effect on all downstream reaches. Long-term watershed scale restoration is generally given priority over near-term reach and site scale activities. However, watershed restoration should not be prioritized to the exclusion of smaller scale restoration. Near-term activities can be pursued in conjunction with watershed scale efforts, but the long-term success of smaller scale activities may depend on completing watershed scale restoration. Watershed scale restoration should focus on watershed-wide restoration of hydrologic function of source areas, improvement of riparian health, restoration of mechanisms for the long-term creation and maintenance of high quality habitat, reduction of fine sediment production, and maintenance of gravel transport continuity.

5.1.a.ii. Reach-Scale Restoration Strategy (Inter-Fluve, Inc., 2013)

Reach scale restoration includes activities that are pursued throughout a reach and that address primary process and habitat deficiencies in that reach. Reach scale activities are prioritized above site scale activities in most cases. Site scale restoration is unlikely to be successful in the long-term without also addressing reach and watershed scale issues. Reach scale restoration is usually prioritized in an upstream to downstream direction, especially for restoration activities that will be common to several reaches. For instance, floodplain regrading and reconnection in upper alluvial valleys would be given priority over the same activity near the downstream end of the study area. This is because floodplain reconnection upstream has the potential for greater cumulative effect on downstream reaches. At the reach scale, restoration strategy is developed with a goal of re-establishing natural processes that will underpin site-scale restoration throughout that reach and those downstream. High priority reach scale strategies include riparian rehabilitation, channel/floodplain reconnection, re-establishing gravel transport continuity, and reducing fine sediment inputs.

5.1.a.iii. Site Scale Restoration Strategy (Inter-Fluve, Inc. 2013)

The site-scale includes projects planned and executed for a specific location within a reach. Site scale work may include several elements such as creation of off-channel habitat, placement of channel margin habitat elements, bank stabilization structures, and riparian revegetation all completed as a single project. Site-scale work should be planned and coordinated with reach and watershed scale restoration activities in mind, and should all contribute to achieving goals at these larger, higher priority scales. If site-scale projects are completed without comprehensive planning, and without completion of restoration at larger scales the potential for success is greatly reduced. It is for this reason that single bank stabilization or single element habitat improvement projects are given low priority in deference to floodplain reconnection projects.

5.1.b. Summary of Short-Term (Reach and Site Scale) and Long-Term (Watershed Scale) Priorities (modified from Inter-Fluve, 2013).

Short-Term Objectives (within 10 years)

- Preserve and Protect - Identify existing areas where high ecological integrity and natural ecosystem processes are intact, and plan to preserve these areas.
- Riparian Rehabilitation - Protect and restore riparian habitat along spawning and rearing streams where the channel geomorphology allows.
- Re-Connect- Re-establish habitat and process connectivity throughout the historic range where feasible and practical.
- Instream Enhancement - Increase habitat diversity and channel function in the short-term by adding instream structures (e.g. large wood, boulders) where appropriate.
- Off-Channel Enhancement - Increase habitat diversity and floodplain function in the short-term by enhancing existing off-channel habitat, or creating new off-channel habitat (e.g. side channels, backwater alcoves) where appropriate and practical.

Long-Term Objectives

- Protect in perpetuity - existing and restored areas with high ecological integrity and natural ecosystem processes including in-channel habitat features, floodplain areas, and riparian areas.
- Establish and protect - a riparian buffer that is appropriate to reach-scale process domain, i.e. wider in alluvial valleys, narrower in canyons.
- Maintain in perpetuity - connectivity through the range of natural habitat where feasible and practical, e.g. discourage new levee, rip-rap, or other hydromodification that would reduce connectivity between habitats and processes.
- Restore natural sediment generation and flux by improving: the watershed road network (logging roads), restoring floodplain connectivity, riparian health, natural bank erosion rates, wood recruitment, and addressing bedload flux.

5.1.c. River Restoration Strategy

Utilizing South Fork Coquille River morphological characteristics from Table 4-4 and the stage of channel evolution, target streamtype, and channel stability of each reach from Table 4-5, the restoration strategy for each reach was determined and is shown in Table 5-1.

Table 5- 1. South Fork Coquille River Restoration Strategy. Reach numbers in this Action Plan correspond with reach numbers in Inter-Fluve, Inc. (2013)[9].

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Restoration Strategy
RM 0-4.8 Interfluve (I) Reach 1 CBS[10]-SFC-1, Jones et al. (2012) - Myrtle Point Reach	Between confluence of North and Middle Forks. Myrtle Point is in this reach.	Successful restoration would involve slightly increasing the stream width, relative to depth, increasing the volume of channel bars, slightly increasing meandering, and the amplitude of meanders, slightly decreasing stream slope and improving floodplain connectivity where possible. Activities such as channel straightening and hardening have delayed attainment of target streamtype. A deeper channel, relative to width was present in the past. However, it is unreasonable to assume that this condition is possible to restore because of high sediment load entering reach, lack of significant amounts of channel lining mature riparian vegetation and channel wood. If the stream narrowed further, the normal flow would flood more easily at multiple points along the reach and landowners may object. In contrast, develop targeted off-channel habitat accessible during high flows that would offer floodplain relief. Instream structures are discouraged due to the amount and timing of water flow and reversing daily tide cycles. Improving large wood (LW) complexity would primarily be limited to off-channel sites where floodflows or tide cycles would not dislodge complexes, resulting in significant loss. Improve riparian vegetation on banks and water influence zone. *Passive:* -Increasing width/depth ratio. -Increasing channel bars. -Slight increase in channel meandering. -Sediment deposition from upriver. -Free to grow riparian vegetation on channel margins and terraces. *Active:* -Reestablish floodplain connection in low bank areas, where feasible. -Reestablish off-channel habitat enhancement, where connection is feasible. -LW placement restricted to off-channel habitat enhancement, where high flows would not result in appreciable loss. -Targeted bank stabilization using structural or bioengineering techniques of selected river bends that maintain maximum meander amplitude needed for a stable streamtype. -Improve riparian vegetation on banks and water influence zone.

[9] A crosswalk of reach numbers can be found in Table 1-3.
[10] CBS = Clearwater BioStudies, Inc.

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Restoration Strategy
RM 4.8-10.2 I-2 CBS-SFC-2, Jones et al. (2012) - Broadbent Reach (partial)	From upstream of Middle Fork to the West Side Road bridge in Broadbent.	Successful restoration would involve improving the stream width, relative to depth, increasing the volume of channel bars, and the amplitude of meanders, decreasing stream slope and establishing an inset floodplain where possible. The most serious deficiency in this reach is the lack of floodplain and the concentration of energy within the active channel during large flood events. Bank erosion at base of high terrace on the outside of meanders bends is beneficial, where distance between successive meanders is increasing toward a target condition. Improve riparian vegetation on banks and water influence zone, with an emphasis on existing or created low terraces. Significant floodflows with high stream energies prevent much instream wood accumulation. Passive: -Increasing width/depth ratio. -Increasing channel bars. -Slight increase in channel meandering -Increasing floodable area within inset floodplain. -Sediment transport/deposition from upriver. -Free to grow riparian vegetation on channel margins, low and high terraces. Active: -Establish greater floodable width beyond the normal channel where feasible and practical, especially on the outside of channel bends, or where there are low areas in the 25-30 ft. high bank terrace. -Reestablish off-channel habitat enhancement, where connection is feasible. -LW placement restricted to off-channel habitat enhancement, where high flows would not result in appreciable loss. -Targeted bank stabilization using structural or bioengineering techniques of selected river bends that maintain maximum meander amplitude needed for a stable streamtype. -Improve riparian vegetation on banks and water influence zone. -Instream structures are discouraged due to the amount and timing of water flow.
RM 10.2-15.3 I-3 CBS-SFC-3, Jones et al. (2012) - Broadbent Reach (partial)	From the West Side Road Bridge to just upstream of Dement Creek	Successful restoration would involve improving the stream width, relative to depth, increasing the volume of channel bars, and the amplitude of meanders, decreasing stream slope and establishing an inset floodplain where possible. The most serious deficiency in this reach is the lack of floodplain and the concentration of energy within the active channel during large flood events. Bank erosion at base of high terrace on the outside of meanders bends is beneficial, where distance between successive meanders is increasing toward a target condition. Improve riparian vegetation on banks and water influence zone, with an emphasis on existing or created low terraces. Significant floodflows with high stream energies prevent much instream wood accumulation. Passive: -Slightly decreasing width/depth ratio. -Increasing alternating channel bars.

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Restoration Strategy
I-3 (Continued)		-Moderate increase in channel meandering. -Increasing floodable area within inset floodplain. -Sediment transport/deposition from tributary streams and upriver. -Free to grow riparian vegetation on channel margins and high terraces. Active: -Establish greater floodable width beyond the normal channel where feasible and practical, especially on outside of channel bends, or where there are low areas in the25-30 ft. high bank terrace. -Reestablish off-channel habitat enhancement, where connection is feasible. -LW placement restricted to off-channel habitat enhancement, where high flows would not result in appreciable loss. -Targeted bank stabilization using structural or bioengineering techniques of selected river bends that maintain maximum meander amplitude needed for a stable streamtype. -Improve riparian vegetation on banks and water influence zone. -Instream structures are discouraged due to the amount and timing of water flow.
RM 15.3-19.6 I-4 CBS-SFC-4 & 0.4 miles of SFC-5, Jones et al. (2012) - Broadbent Reach (partial)	Just upstream of Dement Creek to just upstream of Gaylord Creek.	Successful restoration would identify and prevent anthropogenic disturbance to existing intact riparian areas and channel habitat. Strategy would involve protecting the canyon corridor between RM 15.3-17.0 while enhancing deficient areas within the mature riparian vegetation and large woody material. In the area of more unvegetated alluvial terraces between RM 17.0-19.6, restoration would involve slightly increasing stream length and establishing an inset floodplain at terrace breaks or where two large point bar complexes occur at significant bends in the channel. Improve riparian vegetation on banks and water influence zone, with an emphasis on existing or created low terraces. Well-established riparian vegetation would increase natural bank stability, provide shade, margin cover, and a source of large wood. Complex instream habitat would be provided by large wood complexes, deep scour pools, and margin cover. Passive: -Increasing channel meandering and reduction in slope between RM 17.0-19.6. -Increasing width relative to depth between RM 17.0-19.6. -Sediment transport/deposition from tributary streams and upriver. -Free to grow riparian vegetation. Active: -Protect existing and restored riparian zones. -Improve riparian vegetation on banks and water influence zone. -Establish greater floodable width beyond the normal channel where feasible and practical, especially at terrace breaks or the outside of two channel bends between RM 17.0-19.6. -Instream structures are discouraged due to the amount and timing of water flow.

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Restoration Strategy
RM 19.6-23.5 I-5 CBS-SFC-5, USGS Jones et al. (2012) - Broadbent Reach	Just upstream of Gaylord Creek to near the confluence of Rowland Creek.	Successful restoration would locate and prevent anthropogenic disturbance to existing intact riparian areas and channel habitat. Strategy would slightly increase stream length and decrease stream slope through the reach. Widen inset floodplains at terrace breaks or at the outside of meander bends, and look for other opportunities to improve floodplain connectivity. Improve riparian vegetation on banks and water influence zone. Well-established riparian vegetation would increase natural bank stability, provide shade, margin cover, and a source of large wood. Complex instream habitat would be provided by large wood complexes, deep scour pools, and margin cover. This reach is moderately stable compared to reaches I-1 to I-3 and is more similar to the downstream end of reach I-4. Passive: -Slightly increasing channel meandering, while slightly decreasing stream slope. -Sediment transport/deposition from tributary streams and upriver. -Free to grow riparian vegetation and random treefall. Active: -Establish greater floodable width beyond the normal channel where feasible and practical, especially on low terraces, terrace breaks or outside of channel bends. -Reestablish off-channel habitat enhancement, where connection is feasible. - -Improve riparian vegetation on banks and water influence zone. -Instream structures are discouraged due to the amount and timing of water flow.
RM 23.5-27.6 I-6 CBS-SFC-6 more or less, Jones et al. (2012) - Powers Reach (partial)	From the confluence of Rowland Creek to the bridge crossing just downstream of Powers.	Successful restoration would locate and prevent anthropogenic disturbance to existing intact riparian areas and channel habitat. The river is stable and vertically contained because of impinging hillslopes, even at the 100-year theoretical flood flow. Restoration strategy would slightly increase stream length and decrease stream slope through the reach. Improve riparian vegetation on banks and water influence zone along the canyon rim. Well-established riparian vegetation would increase natural bank stability, provide shade, margin cover, and a source of large wood. Complex instream habitat structures would be provided by large wood complexes, deep scour pools, and margin cover. Passive: -Slightly increasing channel meandering, while slightly decreasing stream slope. -Sediment transport from tributary streams and upriver. -Free to grow riparian vegetation and random treefall. Active: -Protect existing and restore disturbed riparian zones. -Improve riparian vegetation on banks and water influence zone. -Instream structures for each site (ex. LW) would need to be assessed for relative permanence of constructed features.

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Restoration Strategy
27.6-30.6 I-7, CB-SFC-7 more or less, Jones et al. (2012) - Powers Reach (partial)	From the bridge crossing just downstream of Powers and the confluence of Woodward Creek to just downstream of the confluence of Mill Creek	Successful restoration would locate and prevent anthropogenic disturbance to existing intact riparian areas and channel habitat. Restoration strategy would slightly increase stream length and decrease stream slope through the reach. Improve riparian vegetation on alluvial banks and the width of the water influence zone. Well-established riparian vegetation would increase natural bank stability, provide shade, margin cover, and a source of large wood. Complex instream habitat structures would be provided by large wood complexes, deep scour pools, and margin cover. There may be site-scale opportunities to increase channel/floodplain connectivity on low surfaces that do not have residential development. However, development constrains floodplain width , resulting is less floodplain for the rivers discharge during high flows maintaining higher velocities and increased river depth. Passive: -Slightly increasing channel meandering, while slightly decreasing stream slope. -Sediment transport/deposition from tributary streams and upriver. -Free to grow riparian vegetation and random treefall. Active: -Protect existing and restore disturbed riparian zones. -Improve riparian vegetation on actively eroding alluvial banks and the width in the water influence zone. -Instream structures including LW for a given site would need to be assessed for relative permanence of constructed features.
RM 30.6-35.1 I-8 CBS-SFC-8 more or less, Jones et al. (2012) - Powers Reach (partial)	From just downstream of the confluence of Mill Creek to the confluence of Upper Land Creek (near the boundary of the Rogue River-Siskiyou National Forest).	Successful restoration would locate and prevent anthropogenic disturbance to existing intact riparian areas and channel habitat. Restoration strategy would improve riparian vegetation on alluvial banks and the width of the water influence zone. Well-established riparian vegetation would increase natural bank stability, provide shade, margin cover, and a source of large wood. Complex instream habitat structures would be provided by large wood complexes or boulder clusters forming deep scour pools, gravel retention areas and margin cover. Probable locations for such construction of such habitat elements include areas such as channel expansions, pools, and other areas where velocity slows and hydraulic forces are reduced. There may be site-scale opportunities to increase channel/floodplain connectivity on low surfaces. Passive: -Free to grow riparian vegetation and random treefall. -Sediment transport/deposition from tributary streams and upriver. Active: (continued below)

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Restoration Strategy
I-8 (Continued)		Active: -Protect existing and restore disturbed riparian zones. -Improve riparian vegetation on actively eroding alluvial banks and the width in the water influence zone. -Tree tipping for a given site to increase LW, would need to be assessed for relative permanence -Large woody material would be added to the channel as margin complexes wherever feasible. -Instream structures including LW or boulder clusters for a given site would need to be assessed for relative permanence of constructed features.
RM 35.1-38.2 I-9	From the confluence of Upper Land Creek (near boundary of the Rogue River-Siskiyou National Forest) to the confluence of Sand Rock Creek where slope increases abruptly.	Riparian vegetation restoration strategy is limited by canyon and inner gorge features that control set back distances of riparian vegetation. Well-established riparian vegetation would increase natural bank stability, provide shade, margin cover, and a source of large wood. Complex instream habitat structures would be provided by large wood complexes or boulder clusters forming deep scour pools, gravel retention areas and margin cover. Probable locations for such construction of such habitat elements include areas such as channel expansions, pools, and other areas where velocity slows and hydraulic forces are reduced. Passive: -Free to grow streamside riparian forests for thermal regulation, LW supply, sediment filtering, favorable microclimate, and nutrient cycling. -Sediment transport/deposition from tributary streams and upriver. Active: -Protect and maintain streamside riparian forests for thermal regulation, LW supply, sediment filtering, favorable microclimate, and nutrient cycling. -Tree tipping for a given site to increase LW benchmarks, would need to be assessed for relative permanence. -Large woody material would be added to the channel as margin complexes wherever feasible. -Instream structures including LW or boulder clusters for a given site would need to be assessed and assembled for relative permanence of constructed features.
RM 38.2-52.6 I-10	From the confluence of Sand Rock Creek to the confluence of Panther Creek.	Riparian vegetation strategy would protect the well-established riparian corridor that provides shade, and a source of large wood. The riparian vegetation restoration strategy is limited by canyon and inner gorge features that control set back distances of riparian vegetation. The high river gradient and resistant bed and banks control lateral and vertical movement, which creates powerful stream energies during floodflows that may wash out all but the best-anchored pieces or jams, limiting large woody debris restoration. Complex instream habitat structures by large wood or boulder clusters that form deep scour pools would provide gravel retention areas and margin cover. Probable locations for construction of such habitat elements include channel expansion sites, pools, and other areas where velocity slows and hydraulic forces are reduced.

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Restoration Strategy
I-10 (Continued)		Passive: -Sediment transport from tributary streams and upriver. -Free to grow streamside riparian forests for thermal regulation, LW supply, sediment filtering, favorable microclimate, and nutrient cycling. Active: -Protect and maintain streamside riparian forests for thermal regulation, LW supply, sediment filtering, favorable microclimate, and nutrient cycling. Areas where riparian vegetation has been removed, including tributary drainages, should be re-vegetated with a focus on conifers that will provide shade and a source of large wood in the future. -Instream structures including LW or boulder clusters for a given site would need to be assessed and assembled for relative permanence of constructed features.
RM 52.6-55.3 I-11	From the confluence of Panther Creek to the confluence of Buck Creek.	Riparian vegetation strategy would protect the well-established riparian corridor that provides shade, and a source of large wood. The riparian vegetation restoration strategy is limited by canyon and inner gorge features that control set back distances of riparian vegetation. The confined river and resistant bed and banks control lateral and vertical movement, which creates powerful stream energies during floodflows that may wash out all but the best-anchored pieces or jams, limiting large woody debris restoration. However, this reach is slightly more favorable than reach I-10 due to a lower gradient, less watershed area that corresponds to less floodflow and less entrenchment, allowing some narrow alluvial floodplains to form. Complex instream habitat structures by large wood or boulder clusters that form deep scour pools would provide gravel retention areas and margin cover. Probable locations for construction of such habitat elements include channel expansion sites, pools, and other areas where velocity slows and hydraulic forces are reduced. Passive: -Free to grow streamside riparian forests for thermal regulation, LW supply, sediment filtering, favorable microclimate, and nutrient cycling. -Sediment transport/deposition from tributary streams and upriver. Active: -Protect and maintain streamside riparian forests for thermal regulation, LW supply, sediment filtering, favorable microclimate, and nutrient cycling. Areas where riparian vegetation has been removed, including tributary drainages, should be re-vegetated with a focus on conifers that will provide shade and a source of large wood in the future. -Instream structures including LW or boulder clusters for a given site would need to be assembled for relative permanence of constructed features. This reach is more favorable to retain substrate than reach I-10.

River Mile (RM) Reach Numbers (from Different Studies)	Reach Description	Restoration Strategy
55.3-60.4 I-12	From the confluence of Buck Creek to just upstream of Foggy Creek and the headwaters of the South Fork Coquille River.	Riparian vegetation strategy would protect the well-established riparian corridor that provides shade, and a source of large wood. The confined river and resistant bed and banks control lateral and vertical movement, which creates powerful stream energies during floodflows that may wash out LW pieces or jams, limiting large woody debris restoration. However, this reach is slightly more favorable than previous reaches due to a lower gradient, less watershed area that corresponds to less floodflow, and less entrenchment, allowing some narrow alluvial floodplains to form. Complex instream habitat structures by large wood or boulder clusters that form deep scour pools would provide gravel retention areas and margin cover. Probable locations for construction of such habitat elements include channel expansion sites, pools, and other areas where velocity slows and hydraulic forces are reduced. Passive: -Free to grow streamside riparian forests for thermal regulation, LW supply, sediment filtering, favorable microclimate, and nutrient cycling. -Sediment transport/deposition from tributary streams. Active: -Maintain streamside riparian forests for thermal regulation, LW supply, sediment filtering, favorable microclimate, and nutrient cycling. Areas where riparian vegetation has been removed, including tributary drainages, should be re-vegetated with a focus on conifers that will provide shade and a source of large wood in the future. -Instream structures including LW or boulder clusters for a given site would need to be assessed and assembled for relative permanence of constructed features. This reach is more favorable to retain substrate than previous reaches.

5.1.d. Stream Shading and Riparian Restoration to Improve Shading

The Stream Shading section of Section 2.2.e. discusses stream shading including existing and potential stream shade (see Figure 2-14, 2-15, and 2-16). Subtracting existing shade from potential shade gives a scope for improvement. A map of the scope for improvement is shown on Figure 5-1.

Patterns evident in the figures and recommendations for restoration to improve stream shading include (Clearwater BioStudies, Inc., 2003):

- The presence of stream segments with significant scopes for improvement in shade conditions through most of the mainstem and at locations within each of the tributary watersheds. The greatest scope for improvement in the study area was an opportunity to increase stream shading by 73% along one of the modeled stream segments in a tributary system.
- The presence of more extensive opportunities for improving shade conditions in the Dement Creek system than in the other two tributary watersheds.

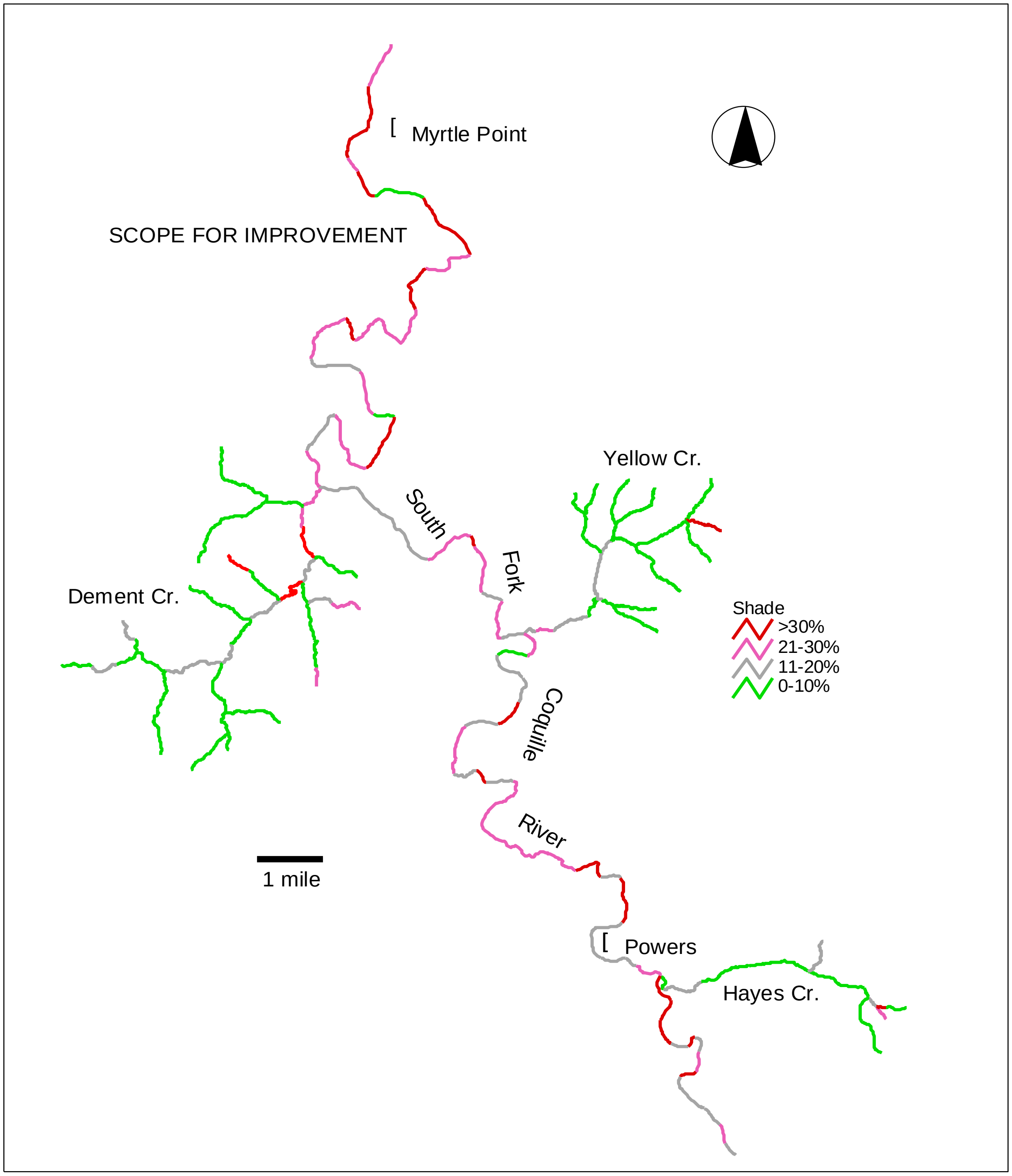


Figure 5- 1. Spatial variation in scope for improvement in stream shading within the lower South Fork Coquille River study area (Figure 22 in Clearwater BioStudies, Inc., 2003).

5.2 SocioEconomic Factors to Consider in Restoration Approach

5.2.a. Landowner Involvement

There are diverse landowners in the South Fork Coquille Watershed including federal ownership (managed by the Bureau of Indian Affairs, BLM, and USFS), and private ownership (see Figure 1-2). Successful river and tributary restoration projects would involve interested landowners, and possibly multiple landowners depending on the project. A landowner agreement would be necessary to ensure agreement on issues related to the restoration. A copy of the most recent landowner agreement is available at the Coquille Watershed Association office or the office of whoever is the lead agency on a project.

5.2.b. Partners

The advantage of having many partners in a restoration project is the different expertise that each partner can bring to the table for design, implementation, and funding strategies. The Coquille Watershed Association office would be able to direct interested parties to some of the potential partners for projects in the South Fork Coquille Watershed.

5.2.c. Funding

There are many possible funding sources available. The Coquille Watershed Association (CWA), Coos Soil and Water Conservation District (SWCD), or the Natural Resource Concervation Service (NRCS), all in Coquille, Oregon can help a landowner learn about some of these possible sources.

Coquille Watershed Association (CWA)	541-396-2541
Coos Soil and Water Conservation District (SWCD)	541-396-6879
Natural Resource Conservation Service (NRCS)	541-396-2841

The design of a project may be constrained by the type of funding source. For instance, the funding source may only be available with certain designs or certain partners that require specific designs. A complicated project may also require an engineer or other specialist for design needs. This extra level of design would require allowing for extra time and extra funding in order to complete the project. There may also be needs for specific innovative approaches to the restoration project design due to ecological conditions (such as portable fencing for seasonal livestock exclusion in some flood-prone pastures (See Chapter 6 – Riparian Fencing), and certain specific funding may be available for some of these innovative projects. Funding for portable fencing and other removable practices may be difficult to secure.

5.2.d. Conflicting Instream Users

There are many instream users to consider when designing instream and riparian restoration projects. These include, but are not limited to: mineral claims (see Chapter 1), gravel extraction (see Chapter 2), boating, swimming, and fishing.

While the South Fork Coquille does not meet the federal test of navigability for purposes of State ownership of the underlying submerged and submersible land (Oregon Division of State lands (Oregon DSL), 2014a, see Chapter 1), according to the State, any waterway is "navigable-for-public-use" if it "has the capacity, in terms of length, width, and depth, to enable boaters to make successful progress through its waters" (Oregon DSL, 2014b). Navigable-for-public-use means that the waterway can be used for navigation, commerce, or recreation and make "reasonable, incidental use of the bed and banks" up to the high water mark (Oregon DSL, 2014b). The courts determined that Navigable-for-public-use includes swimming and boating in small boats for pleasure and fishing (Oregon DSL, 2014b).

5.2.e. Cultural Resources and Native Burial Sites

The State of Oregon has been occupied by humans for thousands of years. Prior to European settlement, native people lived, hunted, fished, and gathered along the Coquille River and its tributaries, and left irreplaceable (and in some cases sacred) cultural resources behind. According to the Oregon Legislative Commission on Indian Services (CIS), conservation practitioners are among the most likely people to inadvertently discover, among other Cultural Resources, possible Native American burial sites in Oregon (Quigley, 2014).

Historic and pre-contact Cultural Resources are protected by a range of federal and state laws. Ground-disturbing projects in the South Fork Coquille Watershed should be pre-screened through landowner interviews and local knowledge including Coquille Tribe contacts. Where agency funds are involved, pre-screening should be conducted through approved agency protocols to determine whether there is a likelihood of disturbing known cultural sites. The Oregon State Historic Preservation Office (SHPO) reviews permit applications and may require a visual survey or other investigation by a qualified archaeologist prior to ground disturbance. The cost of such surveys and reports should be incorporated into a project budget.

In general, cultural resources must not be disturbed without a permit issued by the Oregon SHPO. Mitigation and other requirements for projects that disturb cultural items must be negotiated through SHPO.

Special considerations for unintended uncovering of possible native burial site:

If suspected human remains or burial goods are uncovered, state law requires that Oregon State Police be notified. If there is a possibility that the remains or goods uncovered are Native American, ORS 97.745 (4) requires additional notification to Oregon SHPO and to the Legislative Commission on Indian Services (CIS). The CIS Director will provide appropriate contact information for the Tribes with current or past connections to the region.

If a suspected native burial site is uncovered, the site should not be further disturbed but the location should be documented so it can be reported. If a site is discovered, do not photograph the remains or goods, as photography may be culturally insensitive in some situations. The re-interment and repatriation of native burial goods and remains must be handled in accordance with inter-governmental agreements and Tribal law. For further information on inadvertently uncovered native human remains and the processes to follow, see the Oregon Legislative CIS website and fact sheets (Oregon CIS, 2014). More local information about Coquille tribal history and culture is available through the Coquille Indian Tribe Cultural Resources Program, part of the Tribe's Department of Culture, Education, and Library Services.

5.2.f. Existing Infrastructure

The South Fork Coquille Watershed contains many roads, bridges, towns, neighborhoods, facilities, and other infrastructure. Many of these are permanent in nature and cannot be removed, but need to be accommodated for in restoration design.

5.2.g. Water Rights

To ensure adherence to water rights, existing water rights and diversions on the ground should be reviewed before a restoration project is designed (see Chapter 2).

5.2.h. Permitting

Depending on scope and complexity of a restoration project, different permits may be required. The more complex the project, the longer the project may take to complete due to the time it takes to obtain more permits. Permits for a restoration project may need to be obtained from the U.S. Army Corps of Engineers (ACOE), National Marine Fisheries Service (NMFS), DEQ, ODFW, Oregon DSL, Oregon SHPO, Coos County for Land Use, and Coos County if in a FEMA designated floodplain (FEMA, 2009).

Section 401 of the federal Clean Water Act requires that any federal license or permit to conduct an activity that may result in a discharge to waters of the United States must first receive a water quality certification (WQC) from the state in which the activity will occur in order to ensure the project meets water quality standards. In Oregon, DEQ is the agency responsible for issuing this certification.

A proposal to remove material from, or place fill into, waters of the State requires a Joint Permit Application to the U.S. Army Corps of Engineers and the Department of State Lands. DEQ's Section 401 Water Quality Certification (WQC) process is triggered when U.S. ACOE makes a determination that an application requires a 404 permit. Federal permits cannot be issued without a 401 WQC from DEQ. DEQ coordinates with the Oregon DSL when a federal nexus does not trigger the 401 certification. In this situation, the Department of State Lands includes water quality protection language in their fill and removal permits.

The information contained here regarding permitting was accurate at the time of publication. Always check with permitting agencies before beginning a project.

5.2.i. Opportunities

There are land trusts and other easement opportunities available in this area to aid with the scope and complexity of restoring land and water supplies in the South Fork Coquille Watershed.

5.2.j. Project Screening Criteria

The following table (Table 5-2) provides a simple screen through which proposed projects can be sifted and has been modified from the Coquille Watershed Association Action Plan (CWA, 1997). The criteria in this screen are listed below in order of importance, from top to bottom (most important to least important). This table may be used as a checklist to determine the overall strength of a proposed project. It may not be necessary for a project to meet all of the criteria listed below, but it should be considered that projects which do not meet the ‘most important’ criteria will have a far less likely chance of success (CWA, 1997). At the end of this process, only projects which meet a majority of the screening criteria in Table 5-2 below may be considered.

Table 5- 2. Project screening criteria (modified from CWA, 1997).

Project Screening Criteria	**Yes**	**No**
The landowner(s) desire restoration projects on their property.		
The project is consistent with the Restoration Key		
The project involves neighboring landowners' cooperation or multiple landowners within a reach and meets watershed level objectives		
The landowners' stewardship incentives are high, e.g., the landowners can provide in-kind services such as labor, equipment and materials, or desire to provide long-term maintenance and/or monitoring.		
The project will focus on high priority salmonid habitat and/or water quality limited streams.		
The project addresses limiting factors.		
Projects are technically sound with clearly defined goals and objectives and compatible with watershed scale processes.		
The opportunities are good for coordinating efforts with private, federal, and state groups to treat/restore sub-watersheds or reaches.		
There is a high likelihood of being able to achieve cooperative funding from multiple sources, within a realistic timeline.		
Projects embrace and define a broad spectrum of values, supporting educational, cultural, scientific, and economic goals and objectives.		
Those projects which promote public awareness and participation and enhance educational opportunities associated with watershed health can be considered over those that do not.		

5.3 Restoration Key

While Table 5-1 gives a restoration strategy for each reach, the Restoration Key (Figure 5-2) gives the reader the ability to determine site-specific type of restoration recommended. When using the Restoration Key be sure to read the section “How to use this Restoration Key” on the first page of Figure 5-2 which will give you detailed instructions on how to proceed through the Key.

COQUILLE ACTION PLAN RESTORATION KEY

How to use this Restoration Key:

This Restoration Key was developed for the South Fork Coquille River watershed (HUC 10) by BLM hydrologist Daniel Carpenter and is arranged in seven primary sheets, with two additional sheets of explanatory figures. A definitions section is at the end for understanding technical terms.

Begin in lower left corner of each sheet, starting with sheet one, and follow the dichotomous decision tree to other sheets indicated, as necessary. "Yes" responses proceed up. "No" responses go across or down. Sheet 2, addressing channel crossing structures, proceeds through a logical decision tree loop. Each sheet includes *Notes* pertinent to that sheet.

Inter-Fluve Inc. reach numbers (I-1 to 12) are identified and tracked as a starting point in the sorting process, beginning downstream at the confluence with the North Fork Coquille and proceeding to the headwaters.

Three tables aid in the interpretation of this Restoration Key: A. South Fork Coquille River Morphological Characteristics, B. South Fork Coquille River Channel Evolution, Target Streamtype and Channel Stability, and C. South Fork Coquille River Restoration Strategy.

All river and streams in the world have on-going simultaneous changes occurring; including adjustments in stream width, depth, velocity, discharge, slope, sinuosity, sediment size and sediment load. Many concepts used in this Restoration Key are developed from Rosgen Stream Classification (1996) and other hydrology, hydraulic and geomorphological restoration concepts.

Future target river streamtype (Rosgen 1996) is an interpretation made by a professional hydrologist based upon channel evolution (Simon & Rinaldi 2006). The current channel evolution "state" and target streamtype are shown in Table B: South Fork Coquille Channel Evolution, Target Streamtype, and Channel Stability. Current channel evolution state reflects the natural and anthropogenic impacts from the past. Future streamtype can match the existing streamtype in reaches that are not far departed from a reference condition; e.g. reaches I-9 to 12. Future streamtype is important because it sets the basis for a set of dimension, pattern, and profile relationships, which are scaled by the discharge, at any point on the river. This information is used to determine if the river is in quasi-equilibrium or degrees of departure and sets principles for a restoration pathway.

The Restoration Key is a logical framework and is for initial planning only. This key does not supplant aerial photography and LIDAR interpretation, hydrology evaluation, or fieldwork to measure and understand local reach morphology and hydraulic conditions.

Daniel Carpenter, current BLM Coos Bay District hydrologist, developed this Restoration Key from available studies on the South Fork Coquille River. Daniel Carpenter has worked for the BLM and US Forest Service as a professional hydrologist for more than 35 years.

Figure 5- 2. Restoration Key for site-specific restoration.

COQUILLE ACTION PLAN RESTORATION KEY

1

Notes:
Sheet 1 suggests a strategy that any restored floodable area is beneficial, based on the current condition where the lower South Fork Coquille River is very entrenched between 20-30 ft. high terraces with an absent to narrow inset floodplain. Control points on channel bends found by stable meander width ratios (which balance channel geometry with discharge) are candidates for bioengineering bank treatments and maintenance of those geometries. Straight sections of river at cross-over points between successive meanders are candidates for riparian restoration to near terrace edge. Otherwise, adjusting river geometry and bank cutting on river bends are not viewed as suitable for near-term restoration. The river cannot reestablish the former floodplain at the top of the high terrace and will build a new lower "inset" floodplain over time.

Outside Bend -Floodplain expansion and slope layback
-Bioengineering bank stabilization, rock, rootwad or log veins
-Low growing herbaceous/shrub cover, willow on floodplain, willow siltation baffles
-Riparian forest above floodplain, riparian fencing
Inside Bend -Low growing cover, willow on point bar
-Riparian vegetation on inside bend terrace, riparian fencing

See definition section for understanding technical terms

Meander Width Ratio near Target Yes
(See figures on sheet 8) **No**

-Let outside of channel bend erode
-Low growing cover, willow on point bar
-Riparian vegetation on inside bend terrace

-Floodplain relief area
-Large wood placement
-Riparian vegetation
-Riparian fencing
-Removal of floodplain Encroachment features preventing water filling

River Bend Yes
No

Off Channel Access to Water Fillable Topography Yes
(See example figures on sheet 9) **No**

-Low growing herbaceous cover, willow colonization on floodplain, willow siltation baffles
-Riparian forest above floodplain

Floodplain Access 2-5 Year Recurrence Interval Yes
(At least partial on one side) **No**

Go to sheet 4

Reach 1-5 Yes
No

Go to sheet 3

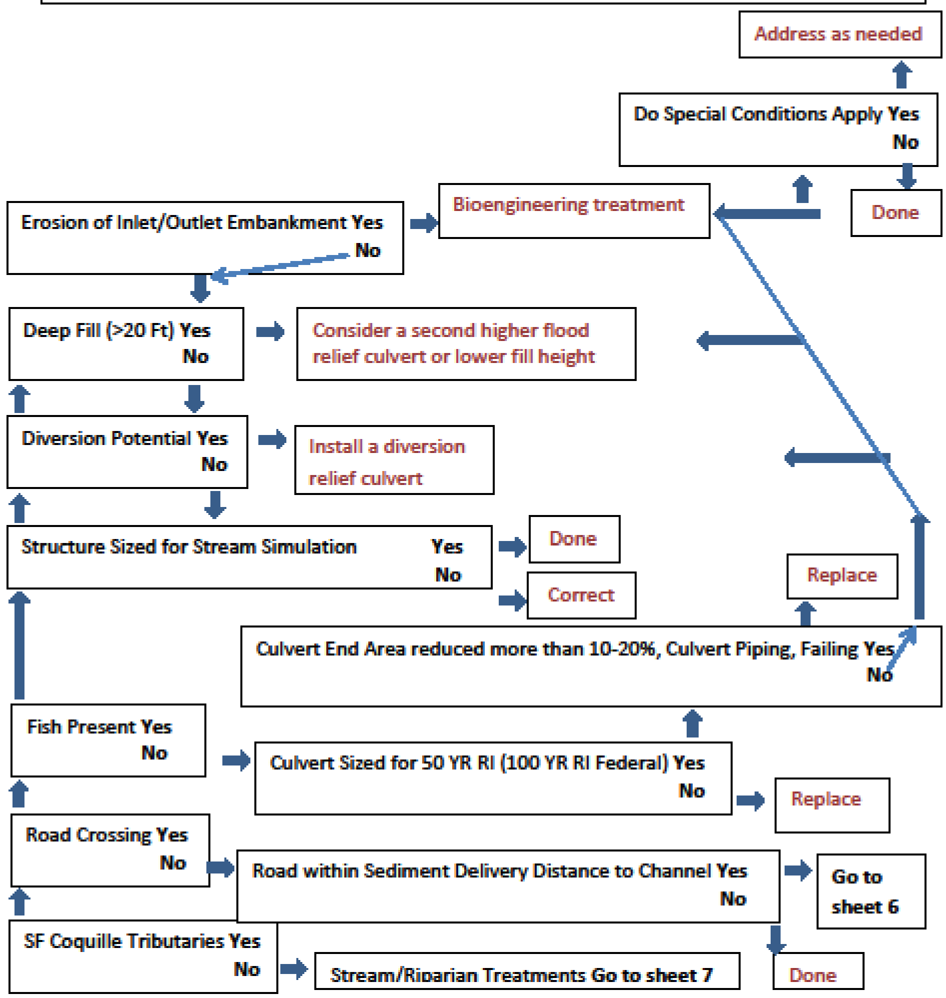
SF Coquille Mainstem Yes
No

Go to sheet 2

COQUILLE ACTION PLAN RESTORATION KEY

2

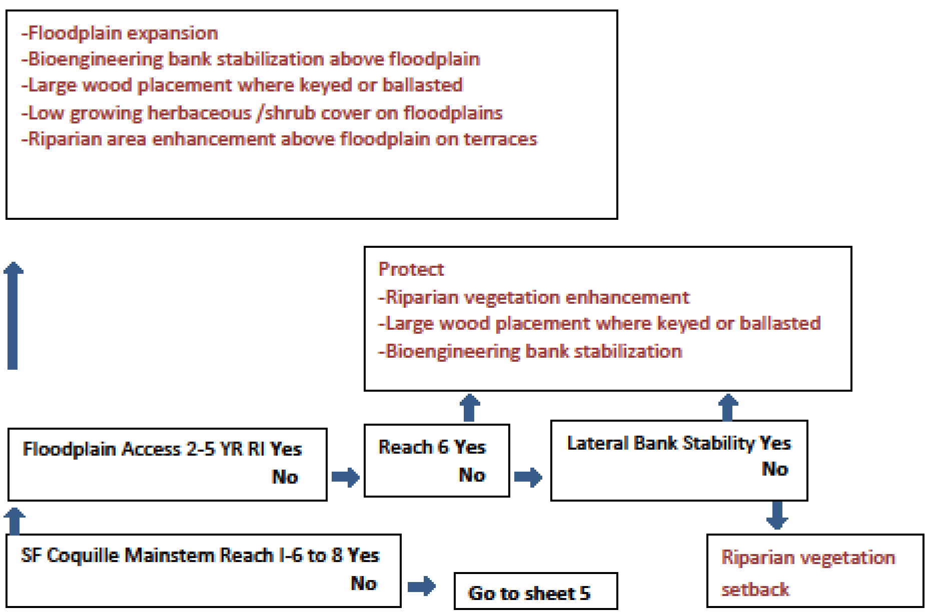
Notes:
Sheet 2 addresses the important features of road crossings over stream channels. Channels with fish present are sized for stream simulation, where the structure width matches the active channel width. Further, there should be a control on the outlet pool that modifies the hydraulic jump or backwatering into the structure, depending upon the streamflow level, while allowing for fish passage for most streamflows. Special conditions of bridge/culvert structures should always be investigated including flood frequency, diversion potential, deep fills, and embankment protection.



COQUILLE ACTION PLAN RESTORATION KEY

3

Notes:
For reaches I-6 to 8 the SF Coquille has more canyon-like features. Lateral and bed stability are moderately high due to the occurrence of resistant hillslopes and surface bedrock. Gravel deposits are mainly narrow point bars and some elongated mid-channel bars or alternating bars. The channel may be undergoing slow bed degradation but limited widening. Mainstem stream energies are still very high due to the discharge and moderate entrenchment, so care should be taken with bioengineering margin cover or river log jams at floodplain or canyon expansion areas.



COQUILLE ACTION PLAN RESTORATION KEY

4

Notes:

Much of the lower SF Coquille is "inset" between the walls of 20-30 ft. high terraces with no floodplain present, or perhaps narrow elongated alternating bars. During peakflows there is too much water velocity and stream energy to mobilize the bed and cut into the nearly vertical terrace banks. Sheet 4 attempts to narrow the search and find stable sites where the terrace will not be appreciably undermined and lost with expanding streamflow. The most stable places where little floodplain is present at normal flood levels (2-5 RI) are at the cross-over in the wide swings of a meander wavelength. These areas may be suitable to planting to near the terrace edge. Where the terrace is lower (generally <15ft.) bioengineering bank stabilization methods may be successful. It is expected that bank erosion will continue to create a target streamtype where the belt width expands and an inset floodplain begins to develop. Because the SF Coquille discharge is too high at times for the normal channel, there is no other practical method to create an inset floodplain and achieve a F4 to C4 (Rosgen) streamtype conversion without bankcutting. Thus, some bankcutting should be viewed as a normal consequence from the current state of river evolution to a more stable target state. The moderately entrenched canyon reach between MP 15.0-17.3 is suitable for riparian vegetation enhancement or bioengineering margin cover that can withstand high water velocities.

-Bioengineering bank stabilization
-Riparian area enhancement to terrace edge

High Terrace <15 Yes
No

Riparian vegetation enhancement to near terrace edge

Protect
-Riparian vegetation enhancement on non-vertical streambanks
-Large wood placement where keyed or ballasted

Straight Section of River near Midpoint between Two Successive Meanders Yes
No

Reach 4, MP 15.3-17.0 Yes
No

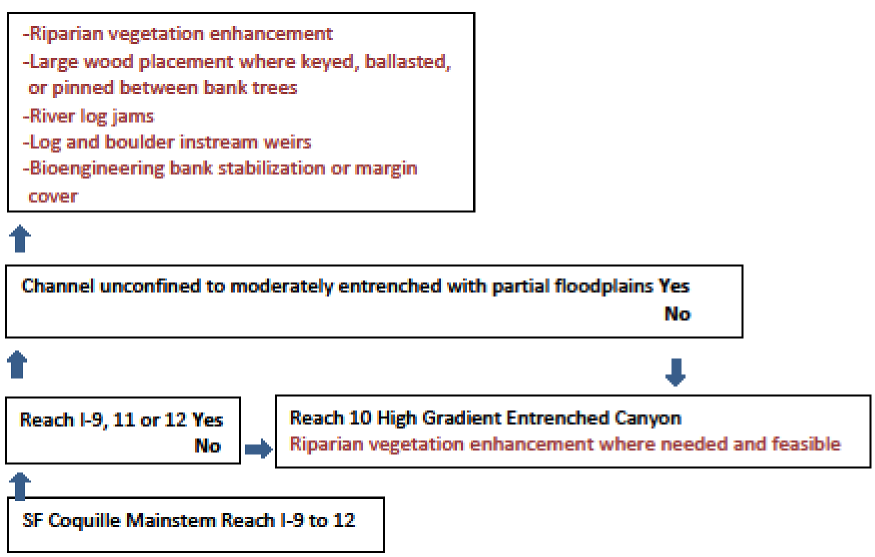
Riparian vegetation enhancement with terrace setback

SF Coquille Mainstem Reach I-1 to5 No Floodplain Access 2-5 YR RI

COQUILLE ACTION PLAN RESTORATION KEY

5

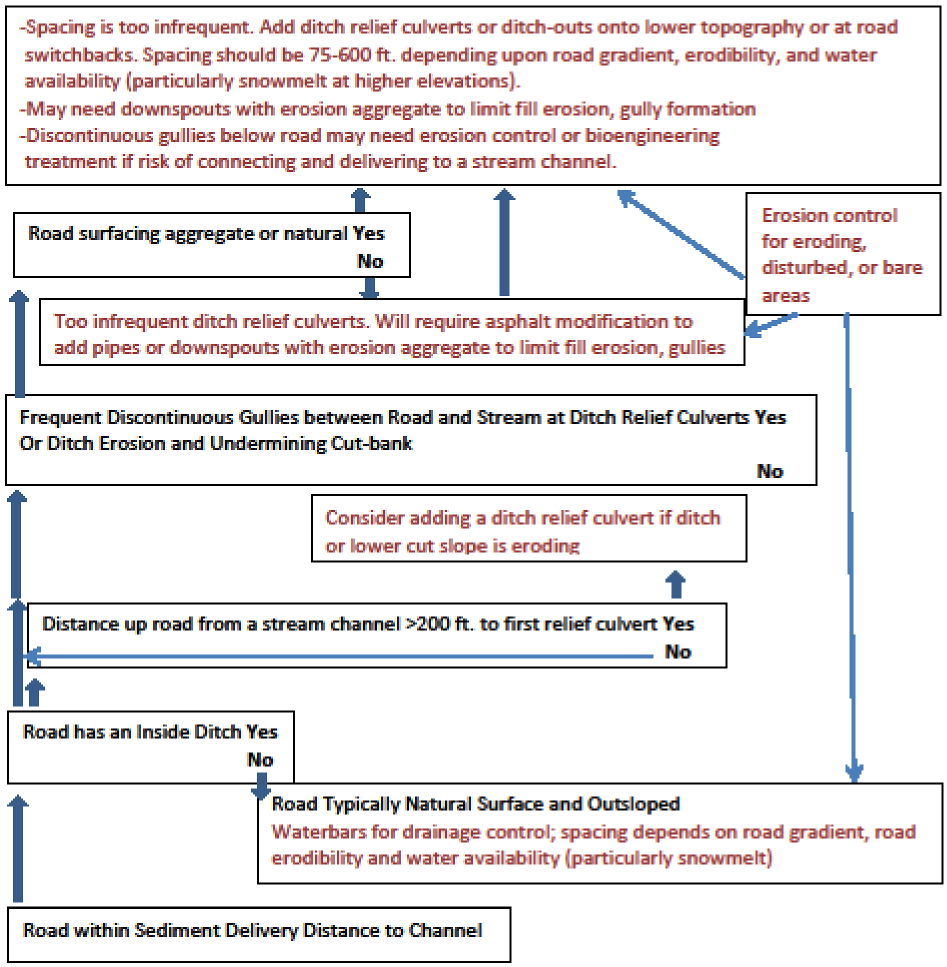
Notes:
Reaches I-9 to 12 are canyon reaches with narrow valley widths, nearly vertical canyon walls in places and steep riffles, cascades and pools. Reach I-10 has river gradients up to 8% and includes Coquille Falls. Large wood placement is not suitable in this reach due to the high water velocities and stream power. Reaches I-11 and I-12, near the headwaters of the SF Coquille are not as entrenched, the valley width expands in places with occasional narrow floodplains. The valley widens at the downstream end of I-12 at Ash Swamp where there is a floodplain with alluvium. Reaches I-11 and I-12, being near the headwaters, have less water flow due to contracting drainage area, are more suited to large wood/boulder placement, river log jams or other bioengineering bank stabilization for aquatic habitat creation.



COQUILLE ACTION PLAN RESTORATION KEY

6

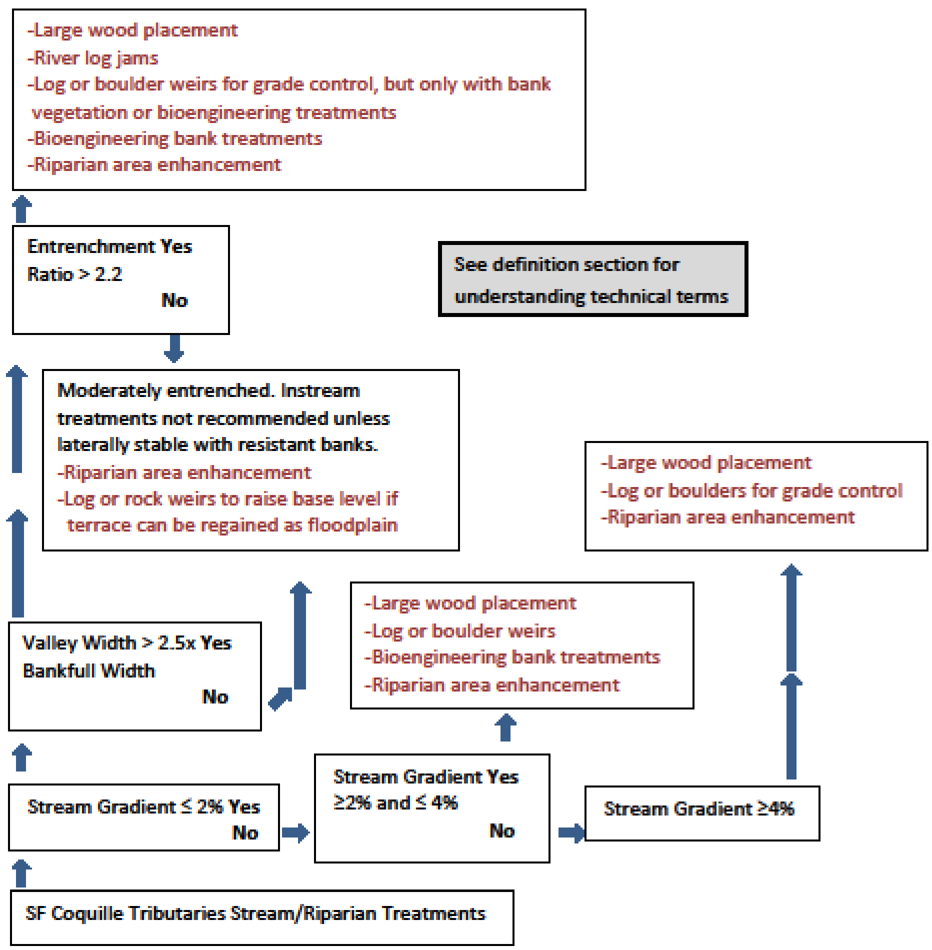
Notes:
Sediment delivery to streams from crowned roads with an inside ditch (most common) occurs when the spacing of drainage relief culverts are too far apart, allowing higher water velocities during runoff that may mobilize sediment. Outsloping is a typical road construction technique for temporary natural surface roads where no inside ditch is present. For these roads, the installation of waterbars are a method to direct concentrated water flow off roadways onto natural ground without gaining downslope momentum along the road surface that may cause rilling and gullying. The strategy seeks to detect where these conditions occur.



COQUILLE ACTION PLAN RESTORATION KEY

7

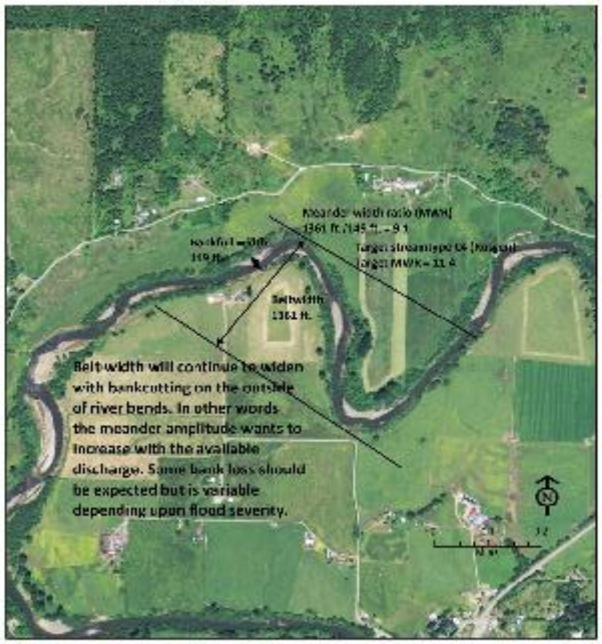
Notes:
Tributary streams have less discharge than the mainstem, where water velocities and stream power are scaled by the stream gradient, resistance of bed and bank materials and vegetation. The low gradient (<2%) streams that are unconfined at floodstage have more treatment options. Moderate gradient (2-4%) streams normally have moderately resistant beds and banks where stability is increased by riparian vegetation. Logs and boulders are appropriate in these streamtypes. High gradient streams normally have resistant bed and banks with high stability and riparian vegetation plays a lessor role in aiding stability.



8

COQUILLE ACTION PLAN RESTORATION KEY

South Fork Coquille Meander Width Ratio
Reach I-II

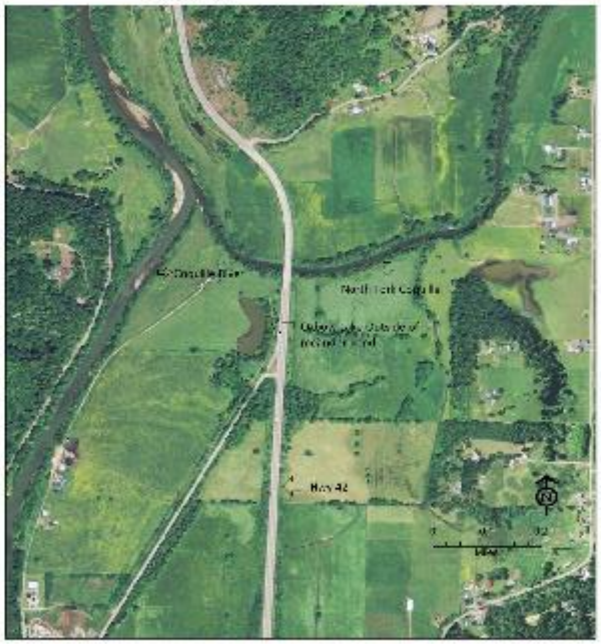


South Fork Coquille Meander Width Ratio
Reach I-II

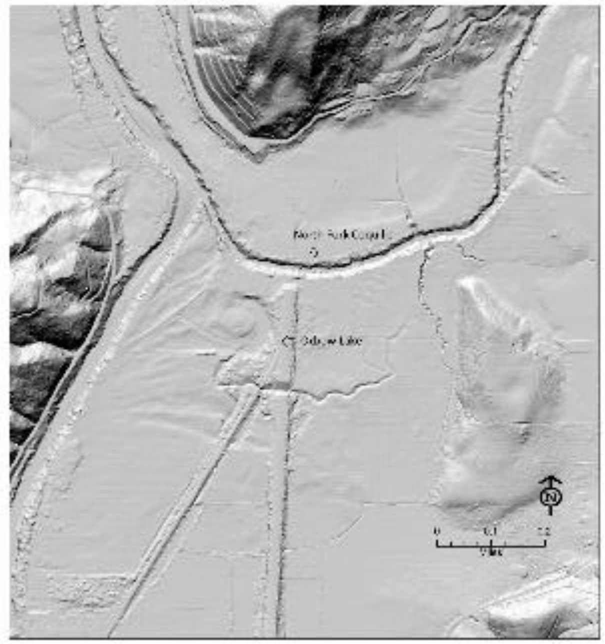
COQUILLE ACTION PLAN RESTORATION KEY

9

South Fork Coquille Oxbow Lake near NF Coquille
Reach I-1



South Fork Coquille Oxbow Lake near NF Coquille
Reach I-1



COQUILLE ACTION PLAN RESTORATION KEY

Definition of Terms

Alluvium A fine grained deposit, sorted by flowing water, including clay, silt or detrital material. Also used to describe the deposition of gravel bars during floods as an alluvial deposit.

Avulsion The sudden breaking of a river or stream through its banks forming another channel. An avulsion usually involves river straightening, increasing stream slope and cutting off channel length and an area of land; e.g. cutting through a point bar at a meander base.

Bankfull The water stage at which a stream just overflows its natural banks or the point of incipient flooding.

Belt Width The distance drawn between two lines drawn tangentially at extreme limits on both sides of a stream channel at successive fully developed meanders (See figures).

Bioengineering A combination of structural and nonstructural techniques used for stabilization. This could be any combination of rock, wood, netting, vegetative bundles, stakes or plantings, seed and mulch. Slope protection and bank stabilization bioengineering can include: vegetation bundles (fascines), live staking, brush-layering, vegetated cribbing, grass rolls and coir logs (netting with mulch inside). Stream edge bioengineering for channel stability can include: log or rock veins keyed into the bank that direct streamflow away, crib walls, tree revetments, root wad placement, poles driven into the stream edge with brush layered behind (palisade fence), and similar structures coupled with vegetation treatments.

Deep Fills Culverts located a substantial distance below the road grade can lead to a fill failure if they become plugged. If the fill height cannot be lowered, then a second higher floodflow pipe may be placed in the road fill to alleviate the ponding against the fill and increased risk of failure during peakflows.

Discontinuous Gully A channel-like feature, formed by an increase in surface runoff where the terminus is upslope and disconnected from a stream channel.

Diversion Potential The potential for streamflow to go out of channel, down gradient along a road inside ditch or drain through a low spot in the road; should the stream crossing structure plug with sediment and debris.

Downspout A erosion resistant travel way that safely conveys discharge across a road fill; usually a full or half round pipe staked to the ground and connected with a ditch relief culvert. Aggregate such as large rocks/boulders can also provide erosion protection below a ditch relief culvert.

Embankment A linear structure, usually of earth or gravel, constructed to extend above the natural ground surface and designed to hold back water or carry a roadway across a channel.

Entrenchment The degree of vertical containment of a river or stream. The containment could be due to canyon walls, resistant well-vegetated hillslopes, or alluvial terraces.

Entrenchment Ratio The ratio of the width of the flood prone area to the surface width of the bankfull channel.

Flood Frequency Analysis The interpretation of a past record of flood events in terms of the future probabilities of occurrence. The analyst tries to fit an appropriate form of probability distribution to the historical record to obtain a best-fit distribution, which then serves as a model for frequency analysis.

Floodplain Relief, Expansion Area Floodable area that is accessed by a 2-5 year recurrence interval peakflow event. These surfaces are very important in the lower river Mainstem (I-I to V) where there is a narrow inset floodplain sandwiched between high terraces that is too narrow for a river of the size of the South Fork Coquille. Without a suitable floodplain, excess stream power during floods can cause vertical and lateral shifts including bed and bankcutting, destabilizing the river.

Definition of Terms *(Continued)*:

Floodprone Area The area that flood water would spread that corresponds to twice the maximum depth of the bankfull channel. This lateral distance usually includes the frequent floodplain and a low terrace and roughly corresponds to the 100 year theoretical flood.

Inset Floodplain The lower SF Coquille is within a 20-30 ft. high terrace that was probably established during the great flood of 1890, when a landslide on Salmon Creek above Powers dammed up the stream, resulted in a dam break flood, and channelized debris flow all the way to the MF Coquille. Splash dam breakouts and land clearing were also contributing factors to the lower river incising below Dement Creek.

Low Growing Herbaceous/Shrub Cover Vegetation that slows water flow on floodplains that can withstand water inundation.

Large Wood Placement Large wood boles, treetops, roodwads and debris delivered to the site, or tipping of bank trees, to improve aquatic habitat.

Mainstem The main South Fork Coquille river trunk stream and riparian corridor.

Meander Wavelength One repetition of a series of sinuous curve or loops of a mature stream, produced as the stream swings from side to side across its floodplain.

Meander Width Ratio The relationship of belt width to bankfull streamflow width (See examples). Unconfined low gradient alluvial stream channels average 11.4, while entrenched low gradient channels average 5.3.

Off Channel Floodable Area Low water fillable topography including where the river cuts across the base of a meander (causing an avulsion) and isolating the oxbow. Oxbows are often connected to the water table and are good candidates for reconnecting to the river and make excellent overwintering habitat as oxbow lakes. Other low topography including former meanders are identified from aerial photography or LIDAR, and sometimes may be reconnected to the river.

Oxbow A former meander abandoned by the river, when the river shortcuts across a meander base causing an avulsion.

Point Bar A ridge of sand and gravel deposited on the inside of a growing meander, while there is migration of the channel toward the opposite outer bank.

Recurrence Interval The selected return period of high streamflows that can overflow banks based upon a flood frequency analysis. A 2-year recurrence interval (RI) runoff may just fill the normal channel with minor flooding and more infrequent events (such as a 5 or 10 RI) may easily overflow onto floodplains, if they are present. A combination of prolonged rainfall and snowmelt lead to the highest runoff.

Reduced Culvert End Area Culverts are flood frequency sized to accommodate a 50 to 100 year recurrence interval peakflow, normally with a factor of safety to accommodate small debris and drift. If the inlet gets too damaged the culvert may be completely full at or below floodstage and even pond with a headwater depth onto the fill. Under these circumstances, the culvert can more easily plug or undermine and pipe through the road fill with possible road failure.

Relief Culvert Conduits (circular corrugated metal pipe are the most common) buried beneath the road surface to relieve drainage in longitudinal ditches at the toe of back slopes. They are crucial to most insloped and crowned road drainage systems and are placed at frequent intervals such that ditch flow does not concentrate to unmanageable levels.

Definition of Terms *(Continued)*:

River Bend Increasing radius to maximum curvature and back again, at the top and bottom of a meander wavelength.

Riparian Forest Near stream forest immediately above lower floodplains that provide shade, a source of large wood, bank stability, nutrients and modify microclimate.

Riparian Setback A wider riparian zone, knowing that the river is laterally unstable and will undercut bank trees with loss of near stream riparian area. Also called terrace setback if the bank is above the floodplain.

Sediment Delivery Distance The distance that concentrated runoff, carrying sediment, may travel; delivered through road ditches and relief culverts or overland flow from compacted surfaces onto natural ground or directly to stream channels. This distance varies, normally from 0-300 ft., depending upon water availability, road gradient, ditch relief culvert spacing, surface compaction, surface roughness and vegetation and soil material erodibility.

Sinuosity The distance of a meandering stream compared to a straight line down the valley. Values are always above 1.

Stream Simulation Stream simulation is an approach to designing crossing structures that creates a structure that is as similar as possible to the natural channel. When channel dimensions, slope, and streambed are similar, water velocities and depths also will be similar.

Water Influence Zone The set-back distance (total width on each side of a stream) where the riparian forest may have an effect upon the stream channel.

Terrace A former floodplain abandoned by the river, and higher than the active floodplain.

Unconfined Streamflows above bankfull, that occur about every other year, that spread onto a floodplain.

Width/Depth Ratio The relationship of stream width at bankfull to mean depth. A stream that is 40 feet wide and an average of 4 feet deep would have a width/depth ratio of 10. Stable low gradient streams with sinuous meander patterns normally average>12. Values much above 20 or <12 are considered unstable (except Rosgen A, G and E type streams).

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Shuh-shiaw Lo. 1992. Glossary of hydrology. Water Resource Publications, Littleton, CO.

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Chapter 6: Design Criteria Guidelines

6.1 Introduction

Since natural processes have been eliminated, altered, or reduced in many areas, aquatic habitat restoration activities are an important method for reintroducing the necessary structure to stream channels that have been simplified due to past management practices and/or disturbance events. Aquatic habitat restoration activities are also a key to the success of the Oregon Conservation Strategy and the Oregon Plan for Salmon and Watersheds (OPSW). In the broad context of the OPSW, habitat restoration includes a multitude of activities. Aquatic habitat restoration activities are intended to address the watershed functions necessary to support healthy watersheds. This includes improving water quality, water quantity, channel complexity, flood plain interaction and the quality of riparian vegetation. The best approach for habitat restoration is to mimic natural events and processes like a windstorm or landslide to guide the structure design. This approach is most effective when the site has all the components for good habitat except for key pieces of wood or boulders to develop complex habitat or limited spawning gravel retention.

Unless otherwise referenced, the majority of restoration guidelines in Chapter 6 were taken from ODFW's Guide to Placement of Wood, Boulders and Gravel for Habitat Restoration (ODFW, 2010).

While this guide provides considerations and tools for the selection and design of these types of restoration projects, it must be noted that there are additional requirements that must be considered prior to final design and construction. With every project there are actions that could have a negative impact if not properly implemented. These are often addressed through conditions that state or federal regulators may impose as part of a permit. These conditions can vary with the permit or exemption used and the project scope and location, thus they are not thoroughly discussed in this guide.

Examples of some types of conditions and best management practices that can be applied to these types of restoration actions to minimize the impacts include:

- prevention and cleanup of petroleum spills
- erosion and sediment prevention and control
- restrictions on when construction can occur
- restoration of construction related disturbance
- providing fish passage
- avoidance of cultural resources

In order to avoid delays in project construction and determine what conditions may be applied to a specific project it is recommended to coordinate with the following agencies during the planning and design process. As mentioned at the start of this document, when projects are part of a forestry operation the local Department of Forestry Stewardship Forester should be the primary contact. For all other projects that meet the DSL exemption the Corps of Engineers Regional General Permit number 3 (RGP 3) would most likely be the permitting option. The

DSL exemption is dependent on certain conditions being met so the rule (OAR 141-085-0534) should be consulted and the local DSL resource coordinator contacted with any questions. The Corps of Engineers RGP 3 includes conditions to comply with the Endangered Species Act, 401 Water Quality Certification, Coastal Zone Certification, and State Historic Preservation Office and Tribal Coordination. Therefore RGP 3 should be reviewed thoroughly prior to project design. Contact the Corps Project manager with any questions to determine if the project can meet all the stipulated conditions.

Other agencies that can add conditions to a project or influence the project design should also be contacted during the design. Early coordination can save both time and money. These agencies are primarily the State Historic Preservation Office, the local planning office, and the Oregon Department of Fish and Wildlife.

6.2 Design Methods

6.2.a. Large Wood Placement

In the last 30 years, it has been learned that large wood is an important part of the forest stream ecosystem and is critical for the survival of trout and salmon that inhabit the streams. Large Wood (LW) diverts water flow, changes water velocity to trap sediment or create pools and providing cover for juvenile fish. Wood loading varies significantly in pristine and managed streams depending on geographic location, fire history, and time since debris flow, floods or windstorms. The best approach to habitat restoration is emulating a natural event like a windstorm or landslide to guide the structure design. So prior to undertaking a large wood project the site, reach, and if possible reference reaches should be assessed in order to ensure the greatest project success.

Logs are typically placed either individually or in groups commonly referred to as log jams. Placement of a single log can provide benefits in certain situations but a log jam typically provides more habitat value. A functional log jam is an assemblage of different logs, branches and leaves of different plant species in different stages of decomposition. This diverse bio-structure provides the base for different aquatic life to find food, shelter, and space to thrive. A log jam also changes water velocity and direction to sort gravels and create pool and riffle habitat.

Designing a Wood Project

The potential effectiveness in changing the stream shape by large wood placement varies with the stream's slope and width. In very steep streams with very large boulders and rocks, log placement will have little impact because the substrate is usually immovable except during extreme flow events. In low gradient or very small streams, the force of the water may not be enough to move sediment to change the shape of the stream. Figure 6-1 outlines a combination of slope and bankfull width measurements where large wood will have the greatest impact on the physical habitat for fish (ideal conditions for habitat improvement), Streams whose measurements are within these parameters have enough slope and width to scour and deposit substrate material, yet probably still retain smaller material, which can be moved around after the large wood placement alters flow paths. Figure 6-1 also shows the combinations of bankfull width and slope that would result in acceptable conditions for large wood placement and those that should be reviewed by an ODFW Fisheries Biologist.

In larger streams, log placement can provide a benefit, but logs will likely need to be stabilized to prevent excessive movement or placed only partly into the water along the edge of the stream. Larger and steeper streams that exceed the parameters identified in Figure 6-1 have more stream flow or power that can lift and move large wood. This makes large wood placement more complex and may require alternative techniques. Projects in these stream reaches typically require agency review and/or approval of the design.

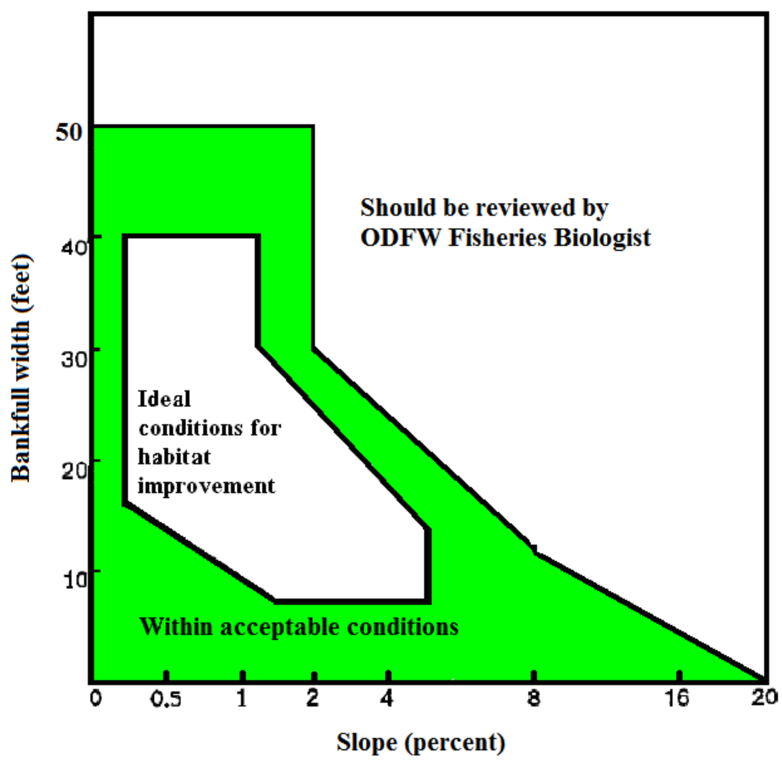


Figure 6- 1. Stream slope and bankfull width which, taken together make for ideal, acceptable, or requires additional review of the large wood placement design that is based on literature review and ODFW fish biologist experience (ODFW, 2010).

Determining Stream Slope

Slope is determined by the change in elevation over a horizontal distance (rise over run). This can be determined by several methods, such as use of a clinometer, bubble level and string, or surveying equipment. If the slope is at the borderline for acceptable conditions, more accuracy may be required to determine the effective restoration technique.

Determining Bank Full Width

Bankfull width is the width of the stream at bank full flow which has the probability of occurring once every 1 or 2 years (Leopold et al., 1995). This is also known as ordinary high water or the point where water starts to flow into the floodplain. In lower gradient streams and in wider valleys where the stream has not cut down below the surrounding land (incised), the bankfull mark usually is where the bank slope changes from steeper to more gentle or even flat (Figure 6-2).

Unfortunately most small streams that are candidates for placement work are either incised or confined by side slopes. This is often seen as the stream channel forming a cross section shaped like a V or a U. In those cases look for clues such as an abrupt change in vegetation, material deposited on the bank or on overhanging branches during high flows. Changes in rock color or an abrupt change in texture of the bed or bank material may also be clues.

Bankfull width (also called an active channel width, ordinary high water or high water level) is measured from one side bank mark to the other (Figure 6-2). The width of large islands that would be dry even under bankfull conditions should be subtracted from the bank-to-bank measurement. To get an accurate bankfull width measure at least 10 points along the part of the stream where the work will be done. The measurements should be at least 1 or 2 channel widths apart covering the length of the project area. Previous stream surveys by ODFW or by other agencies may be used to determine bankfull width.

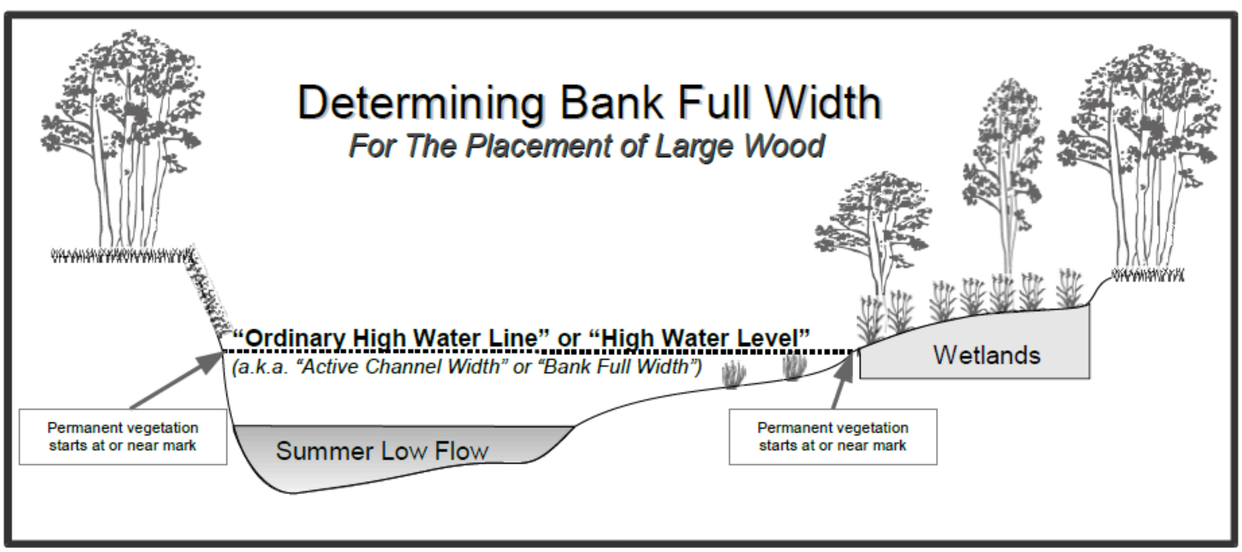


Figure 6- 2. Cross section of a stream with normal and bankfull flow levels indicated. Area above bank full would be considered floodplain (ODFW, 2010).

Diameter

The key to establishing a log jam is utilizing larger diameter wood that resists decay. These pieces of wood are often called “key pieces”, and serve as the anchors for the log jam structure. Conifers (spruce, fir, cedar, etc.) have the potential to last 7 times longer than hardwoods (alder, cottonwood, and ash) given the same diameter and conditions. Therefore, conifers should be used as the key pieces of wood. The combination of conifers and hardwoods increases the complexity of the structure and the hardwoods serve other functions. Since hardwoods break down more rapidly they serve as feeding platforms for a variety of insects increasing biological diversity. Hardwoods also are structurally weaker so during flood events the hardwood pieces will break allowing water pressure to be reduced through the new open area. The smaller pieces move downstream and can be accumulated on the next structure.

Wood can improve fish habitat only if the wood is large enough to stay, influence flow patterns, and sort sediment. Larger diameter wood retains its size longer as abrasion and decay occurs over the years. Larger diameter wood is more effective in creating pools and complex channels that improve fish populations. The minimum diameter required for a key piece of wood depends on the bankfull width of the stream and can be found in Table 6-1.

Table 6- 1. Bankfull widths and minimum diameter of logs to be considered key pieces (ODFW, 2010).

Bankfull Width* Feet	Minimum Diameter* Inches
0 to 10	10
10 to 20	16
20 to 32	18
Over 32	22
*This table was taken from the 1995 A Guide to Placement of Large Wood in Streams (ODFW, 1995).	

Length

The length of the wood is also important to stability. A piece that is longer than the stream is wide is less likely to be carried away when the water is high. To be considered a key piece a log with a rootwad still attached should be at least one and one-half times (1.5X) the bankfull width or a log without a rootwad should be twice (2X) the stream’s bankfull width. As the best fish habitat is formed around jams composed of 3 to7 logs, at least 2 key pieces should be used at each structure. These log lengths require a larger storm event to move them to a new location and have a higher probability of becoming stable at the next meander bend or obstruction. Leaving limbs and branches on the logs also increases stability and provides additional cover for fish. Hardwood logs or smaller trees with branches can be can be added to the structure to accelerate the development of a functional log jam.

Making Wood Placement More Effective

Prior to implementing a wood placement project it is important to evaluate the existing reach condition. It is possible a given stream already has enough wood in it to create multiple functional log jams. In this case the addition of more wood may be of limited resource benefit.

Whenever possible a tree with a rootwad attached should have the rootwad in the active channel. The roots create excellent hiding habitat for juvenile fish. The roots also add to the stability of the structure by maintaining contact with the stream bottom over a wider range of stream flows. In both windthrow and landslides small material is often pinned under the larger trees so coarse wood should be included in the project.

The first few upstream structures capture most of the coarse wood floating downstream and fill in quickly, so the addition of coarse wood is very important for the downstream structures to become fully functional.

Windthrow Emulation

As mentioned earlier, one of the keys to a successful wood placement project is to mimic natural processes. One such option is to mimic the deposit of wood that occurs during windstorms. Windthrow emulation duplicates the result of a tree or group of trees becoming uprooted during a storm and landing in the stream. In a natural process, trees may have only part of the tree in the active channel often with some of the trunk still on the stream bank. The weight of the log on the bank increases the stability and reduces downstream movement. The orientation of the wood is not important because the length and diameter of the wood along with the stream forces will position the wood to form a stable structure. Equipment can manipulate the logs to increase their stability by placing the wood between 2 standing trees that will lock the log in place by creating a pivot and stop point (Figure 6-3 panel A). In addition, one log can be placed on top of another so the weight of the top tree can pin the second tree (Figure 6-3 panel B). This is a simple windstorm emulation that allows the wood to adjust to the stream flow. Complex structures with multiple logs with interlocking pieces of wood provide better habitat and mimic wood accumulation over time. Figure 6-4 provides some ideas on the configuration of the key pieces of wood in a restoration structure.

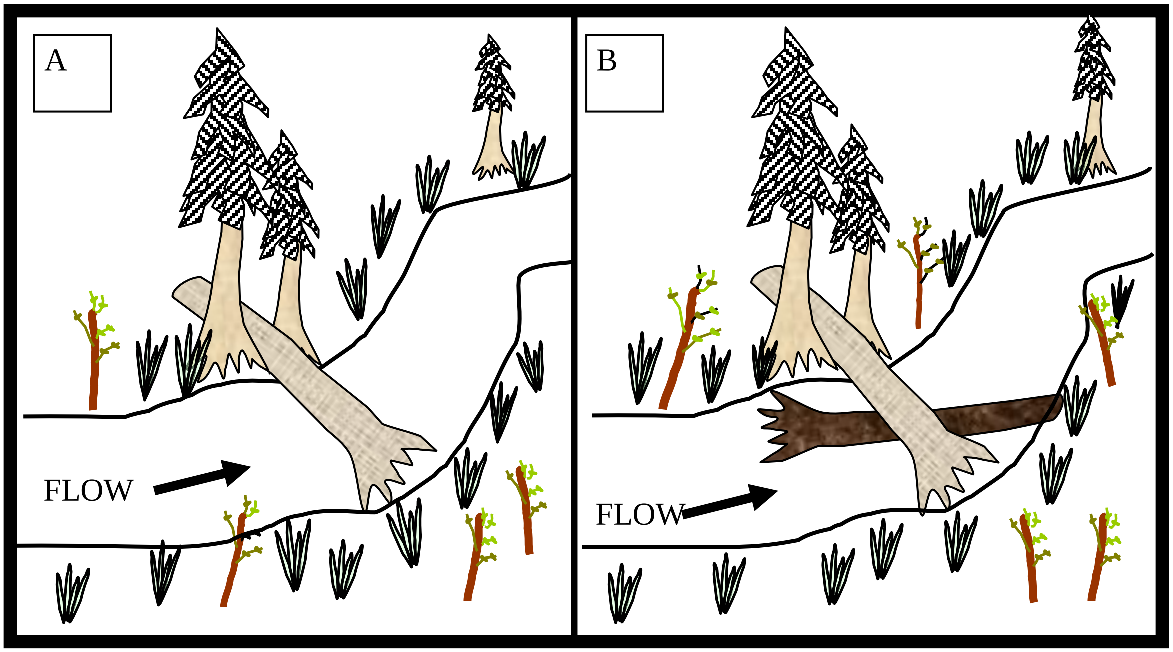
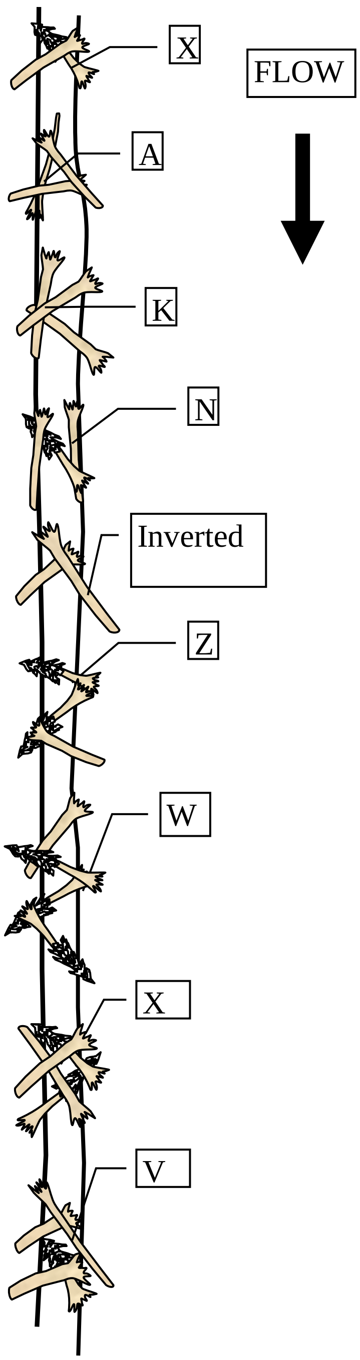


Figure 6- 3. Panel A is single log placed between two standing trees to create a pivot and lock point. Panel B is an X pattern where the weight of the top log pins the bottom log to reduce the movement. Not shown is coarse wood (CW) or limbs that will create better habitat (ODFW, 2010).



Large wood may be positioned in the stream in various configurations. The examples to the left are some patterns that can be used.

For stability, two of the logs should be twice the active channel if they do not have the root wads attached or 1.5 times the active channel if the roots are attached and meet the tree diameter criteria in the guidelines.

The large wood can be placed between standing trees to increase the stability by preventing the logs from rotating downstream.

To increase hiding areas for juvenile fish, it is recommended that the roots or limbs be in contact with the summer flow channel. Coarse wood can be added to the structure if the tree does not have rootwads or limbs.

Figure 6- 4. Typical plan view wood configurations and alphabet codes for use in describing them (ODFW, 2010).

Slide Emulation

Another method to recreate natural processes and ensure project success is to mimic the deposition of material that occurs during landslides. Slide emulation is the direct deposit of wood into the channel and achieves a stable position at constricted or shallow sections of the stream. With the length of the logs being twice the active channel, the first higher water will float the logs to the natural choke points. As the flow rises, more force is exerted on the logs locking them in place. This should not be attempted in streams that are prone to flash flooding. Because this approach allows for the natural repositioning of the logs it should only be used if there are identified choke points that are well upstream of roads. A minimum of two meander curves should be between the last placement and any road crossing. This technique can be very useful where ground based equipment cannot safely reach the stream, where flight hazards prevent helicopter placement at the desired location, or in conjunction with timber harvest that have a cable highline suspended above the stream so that logs can only be lowered in the corridors.

Wood/Boulder Projects

Adding boulders to a large wood project can fill in the gaps to slow down the water by increasing the pool depth and more effectively emulates a slide event. Boulders can be effective at reducing the downstream movement of wood when other anchor points are limited. When adding boulders they should be sized appropriately for the stream and only the minimum amount of boulders necessary to achieve the project objectives should be used.

For stability, it is recommended that key boulders be a minimum of twice the diameter of the average of the ten largest naturally occurring boulders in the project stream reach (measured upstream and downstream of the project site). Projects in the Umpqua River Subbasins found that adding a ½ cubic yard boulder for every 10-foot of tree length provided good results in long-term retention of gravel. Smaller diameter boulders can be used, and remain stable, when added to a wood dominated structure because the wood in the structure can block or slow the flow of water directly on the boulder thereby reducing the pressure against the boulder. The wood can directly support the boulder and limit its movement when the boulder is integrated in the structure. The wood structure also increases gravel retention, which may result in a partially buried boulder having less area exposed to the force of water.

Acquisition

Logs and trees to be placed in streams are best obtained from locations where their removal will not conflict with other valuable functions they might serve. If other trees can fill those functions, streamside trees may be pushed or pulled over into the stream with the rootwads intact. Wood should be repositioned within the riparian area and stream channel only as necessary to alleviate threats to public safety or substantial property damage, provided the habitat and resource value of the wood is maintained in that stream segment. Downed wood serves as refuge habitat for fish and reduces the chances of avulsion, a sudden change in channel location, during extremely high flows.

Adding wood in floodplains and wetlands

In most cases it is beneficial to the stream and riparian environment if wood is not just placed instream but rather in both the stream and on the floodplain along the stream. Large wood placements on the floodplain can serve a number of important functions. Floodplain wood can be used to provide hydraulic roughness that is otherwise lacking due to impacts to floodplain vegetation or past filling and grading. Increased roughness can reduce the energy of overbank flows and reduce the potential for channel avulsions. Floodplain wood can also be placed with the acknowledgement that channel shifting is likely and once it occurs, the wood will be available to function as instream wood (Cramer, 2012). This addition of wood can improve the habitat of many fish and wildlife species, provide refuge habitat during extreme high flows, and provide future wood recruitment. Many watershed professionals look at the entire area where a channel may migrate, this often extends from valley wall to valley wall. Placing wood throughout this entire area is a comprehensive restoration approach and provides habitat and structure to side channels, wetlands, and floodplains that have been lost to development and land use. This approach is most effective in areas where infrastructure or property would not be at risk. However, as with any wood project, in areas where there is development or infrastructure near or downstream of the project area caution must be used to ensure the project does not flood or impact those properties.

River Log Jams

River log jams, also known as engineered or constructed log jams, are typically defined as being comprised of 10 or more pieces of large wood and can also incorporate boulders and anchoring systems. They are discussed separately from placed logs and LW complexes because of their size, complexity, and risk. Figure 6-5 is an example of a river log jam in a large river. Placed large wood and boulders in river log jams create habitat directly, but also use natural processes that scour and deposit bed and bank material to create new stream habitat with immediate and long-term benefits (Cramer, 2012). Commonly used references for designing river log jams include NRCS (2007b), Cramer (2012), and D’Aoust and Millar (2000). There are two excel spreadsheets that can be used for calculations to determine buoyancy and design for river log jams (NRCS, 2007b and Cramer, 2012). These references provide a tremendous amount of detail in regards to designing river log jams and should be reviewed when considering river log jams. The following is a summary of these references.

Figure 6- 5. Significant gravel accumulation one year after construction of a river log jam. (Left) post-construction. (Right) one year after construction (Washougal River, WA, Tony Meyer as cited in Cramer, 2012).

River log jams can be placed within the stream corridor where wood would naturally occur. Researchers have noted that instream structure failures are often due to a poor understanding of stream response to hydrology and hydraulics; a lack of experience and/or documented procedural guidelines (Cramer, 2012). Generally, river log jams work well in alluvial channels having less than a 2% slope and can be used in association with constructed or natural side channels (Cramer, 2012). Jams can be assembled at the inlet of side channels to regulate the amount of flood flow entering the side channel. Log jams can also be used downstream of backwater sloughs or side channels to increase backwater elevation, and thus habitat capacity, in the side channel. River log jams can be used in incised alluvial channels to speed channel evolution and recover aquatic habitat.

River log jams placed in aggrading reaches typically cause rapid channel response and adjustment, including bar formation, split-flows, and channel avulsion or reroute (Cramer, 2012). In particular, the potential risks or benefits associated with avulsions should be considered. Floodplains with immature vegetation, lack of downed wood, and low topographic variability may be more subject to avulsions during flooding. In these systems, a repetitive avulsion cycle can hinder the development of mature floodplain vegetation and may lead to persistent instability that reduces the health and productivity of the stream (Cramer, 2012). In contrast, where the riparian area is healthy, occasional avulsions may be a natural process and may benefit the stream through creation of new habitats and recruitment of substrate, wood, and nutrients to the channel (Cramer, 2012).

The presence of rootwads influences the stability of wood by concentrating much of the mass of the tree onto a relatively small area of the channel bed (Cramer, 2012). In a study of streams draining unmanaged forested basins in Washington, Fox (2001) found that in channels with bankfull widths over 30 m, more than 91% of key pieces had root wads attached. Without rootwads, the minimum volume of stable key pieces would have been much larger. Sedimentation in the "hydraulic shadow" of the rootwad, and sediment often buries the bole of the tree further increasing its stability (Cramer, 2012). Using trees with intact branches will provide additional complexity particularly when using a single wood piece. In addition, the more complex the wood configuration, the more living space, refuge and stability it provides (Cramer, 2012). Green trees in the spring have the most water content and if moved shortly after being felled or pushed over, the branches are more resilient to breakage. Maintaining limbs, however, may be impossible or impractical if wood must be transported by truck. Typically, maintaining limbs is only possible for wood material salvaged on site or transported by helicopter. In situations where large logs are impossible to deliver to a site due to their size, weight, or access limitations, key piece sized wood can be emulated by constructing an artificial large log from smaller logs (Cramer, 2012).

Factors which may influence site selection include access, infrastructure, bank erosion potential, or the condition of riparian vegetation (Cramer, 2012). These conditions are site specific and will require careful analysis by the design team.

The size, shape, orientation, and degree of anchoring of river log jams depend upon many factors including habitat objectives, channel hydraulics, geomorphic response, risk, access, and cost (Cramer, 2012). These factors should be addressed and planned for early in the design process. Public safety is of particular concern in areas where recreational use of the river is high. In particular, care must be taken in certain reaches of the South Fork Coquille where boating for recreation and fishing is a popular activity.

River log jam designs typically consist of three basic elements: 1) one or more key pieces that consist of large immobile logs (ideally with attached rootwads), usually placed more or less parallel to the channel with the rootwads facing upstream; 2) stacked members that consist of logs of varying size placed on top of the key pieces and/or interwoven to form the matrix of the jam; and 3) racked members of smaller wood placed against the upstream face of the jam, generally perpendicular to the direction of flow (Cramer, 2012). Log jams, however, can take many alternative forms depending on project objectives and site-specific conditions. River log jams often incorporate the use of boulders to provide additional weight and stability to the structure.

The desired level of stability for river log jams should be clearly defined and accounted for in project design. In some cases, it may be desirable for jams to function as they do in natural systems, where they are allowed to adjust, move, and even break apart and relocate downstream during floods; in other cases, greater stability may be necessary (Cramer, 2012). The need for and methods of stabilization/anchoring depend on several factors including habitat objectives, risk to property or infrastructure, stream size and hydraulics, the size of material that is available, and the likelihood of future wood recruitment (i.e. replacement) if wood is transported out of the system. Placement of a river log jam on a stream with a downstream bridge or with stream-adjacent residences may need to be stabilized in place to manage for risk to infrastructure and public safety (Cramer, 2012).

Stabilizing instream wood becomes a significant concern on larger streams. Wood placement in the main stem of the channel is only recommended in the form of anchored structures (i.e. log jams, complexes, and wood trapping structures), unless transport can be tolerated. Key pieces and log complexes can be effectively used in side channels and floodplain habitats. Lateral jams, as opposed to full-spanning jams, are a common feature. As with medium-sized streams, locations at the outside of bends and the head of natural gravel bars tend to be relatively stable (Cramer, 2012).

The stability of a structure will increase as its weight increases relative to the buoyant and drag forces acting against it (Cramer, 2012). This can be achieved by placing wood so that some of its weight is supported on banks above the bankfull channel or by stacking wood such that much of it is located above the bankfull channel and not in contact with low to moderate flow events (Cramer, 2012). Burying either end of a log or lateral burial of some portion of its diameter can also pin the log in place, provide ballast, and decrease the fluid drag forces on the log. The more wood above design flow elevations, the more ballast and strength is provided to the submerged portion of the log jam. Attaching boulders to logs also counteracts buoyant forces. If the log structure is sufficiently large and complex, then boulders can be placed in the complex without mechanical anchoring (Cramer, 2012).

Many techniques for anchoring logs and providing stability to jams have been developed. These include burial, backfilling with alluvium, cabling or pinning logs together, and anchoring to bedrock, boulders, pilings, deadman anchors, or existing trees (Cramer, 2012). Consideration should be given when considering anchoring techniques as to what is allowed under Department of State Lands, U.S. Army Corps of Engineers, and National Marine Fisheries Service permitting and regulations (See Section 5.2.h for more information on permitting).

6.2.b. Boulder Placement

In bedrock dominated systems and other areas where it may not be practical or effective to place large wood, boulders can be used to create complexity in the stream. Projects of this type should occur only in channels with intact, well-vegetated riparian areas or be conducted in conjunction with riparian restoration and/or management. This approach needs to be carefully designed to provide stable functional structures and in many cases additional permitting and agency review may be required. In order to ensure fish passage and reduce risks it is recommended an ODFW fisheries biologist be contacted and involved in the planning and design of any such project.

Designing a Boulder Project

Boulder placement is most effective in high energy or bedrock dominated stretches of stream where spawning gravel and summer pool habitat is lacking or where large wood is not readily available. Placing boulders in streams not dominated by bedrock can narrow the channel, increase scour, widen the channel, alter the direction of the thalweg (i.e. the path of deepest flow), cause erosion, and increase channel meandering. The key to success with a boulder project is to ensure that the boulders are sized appropriately for the stream system and placed in clusters or constellations (patterns) that replicate natural stream conditions and do not substantially modify stream hydraulics. In general, boulders should only be placed within stream channels where rock and boulders would naturally occur but are currently lacking.

For the purpose of this guide, boulder structures are not suitable for placement in:

- Low gradient meadow streams. Boulders in meadows warm the water by collecting solar radiation and cause significant changes in channel hydraulics, which can possibly destabilize the channel and banks.
- Gravel rich streams with a high bed load movement. In gravel rich streams scour around the boulders may cause the boulder to move downstream and slide into the new scour hole and eventually become buried by the gravel as it sinks rendering them ineffective (Fischenich and Seal, 1999).
- Stream where the streambed and banks are composed primarily of small gravels, silts, or sands. In these systems the effects of boulders can be unpredictable and require specialized planning and design.
- Unstable, braided or aggrading channels.
- Streams with a gradient of more than 10%.

Boulder constellations can trap gravels at the edges of the stream and narrow the summer flow into defined channels. This results in cooler water by less exposure to daytime air temperatures and increased flow through gravels. On bedrock streams this can turn shallow sheet flow into deeper summer rearing habitat. The water flowing over the top of the boulders during high flow events maintains the pools in the spaces between the sets of boulder constellations. The first sets of boulder constellations may trap most of the bed load, so gravel may need to be added for the downstream boulder sets to become functional. Boulders are effective in capturing gravel where large wood can intercept wood drifting down the stream. The combination of boulders and large wood can turn a bedrock-dominated stream to complex instream habitat with pools, riffles, and cover that can support a wide range of fish species

Boulder Sizing

Boulders can provide stable habitat structures if the boulders are properly sized and oriented in relationship to the stream flow. For stability, it is recommended that key boulders be a minimum of twice (2X) the diameter of the average of the 10 largest naturally occurring boulders in the project stream reach. The intent of this is to identify a size for key boulders that is sufficient to be stable under expected high flows (typically a 25-year recurrence interval). Smaller sizes of key boulders should be used only if a shear stress analysis of the stream reach shows that smaller boulders would be stable at high flows or if the overall project will be stable. In gravel rich streams it may be difficult to determine the size of the boulder because the boulder is partially embedded into the streambed or in bedrock areas there may not be many reference boulders. In those cases or where the 2X boulders are not available, a shear stress analysis of the stream reach may be needed. Shear stress analysis is typically performed by restoration professionals and is used to calculate the size of the boulder that would be stable at high flows. This analysis is especially important if there is a structure downstream such as a culvert or water intake. For the purposes of this guide, boulders must not be permanently anchored (including rebar or cabling to meet size or stability criteria).

Boulders change the water velocity and can be used to create a variety of habitats.

Table 6-2 provides a rough guideline on the stream velocities needed to move different sizes of sediment. By speeding up or slowing down the water velocity, bed load sediments can either be transported or deposited.

Table 6- 2. Approximate threshold conditions for granular material to start moving (adapted from Julien, 1995).

		Diameter		Velocity	
Material	Size	mm	in	m/s	feet/sec
silt	medium	0.0160	0.0006	0.0080	0.0260
sand	fine	0.1250	0.0049	0.0120	0.0390
sand	very coarse	1.0000	0.0394	0.0216	0.0702
gravel	very fine	2.0000	0.0788	0.0360	0.1170
gravel	very coarse	32.0000	1.2600	0.1600	0.5200
cobble	small	64.0000	2.5200	0.2300	0.7475
cobble	large	128.0000	5.0400	0.3300	1.0725
boulder	small	256.0000	10.0800	0.4700	1.5275
boulder	medium	512.0000	20.0000	0.6700	2.1775
boulder	large	1024.0000	40.3500	0.9400	3.0550

Boulder Arrangement

For the purposes of this guide the most appropriate method of boulder placement is to mimic natural boulder accumulations by installing non-full spanning boulder structures such as randomly placed boulders, boulder fields, clusters or constellations that do not restrict fish passage (Figure 6-6). Full spanning structures like weirs, cross vanes, J-hooks, Newberry riffles or other drop structures while useful in certain applications require specialized expertise and significant design considerations for fish passage and stability. More information on full spanning structure can be found at the Washington Department of Fish and Wildlife Habitat Technical Assistance website: (www.wdfw.wa.gov/hab/ahg/shrg/18-shrg_drop_structures.pdf). Even non-full spanning structures when placed at the wrong angle or location can create additional problems that may not be easy to correct. Therefore it is recommended that the local

ODFW biologist be contacted as they can review and make suggestions on the proposed structures and identify possible advantages and disadvantages. Finding a reference reach near the project site, where boulders are providing the desired habitat, will also increase the likelihood of success of the project.

In order to ensure the most effective and least problematic design, the following criteria should be followed when designing and implementing a project. Individual boulder constellations should not exceed 1/3 of the active channel width and not shift the stream flow to a single flow pattern in the middle or to the side of the stream. If the channel is narrowed to one pathway, it will increase the velocity, can cause excessive erosion, and can simplify the stream habitat. Boulder constellations should be positioned so that they are staggered and not placed along just one side of the channel. A minimum of a 2-foot gap should be maintained between constellation structures. These design elements create alternating paths of water flow, allow the water to be concentrated in a travel pathway for adult and juvenile passage, and provides resting areas for juvenile fish. This concentrated flow allows passage during low flow periods therefore no more than 25% of the cross-sectional area of the flowing channel at the time of installation (e.g. low flow channel width) should be blocked. The use of coarse wood placed under the boulders may extend into these fish passage gaps to increase the recruitment of gravel. Smaller (12-18 inches) rock may be placed upstream from the gaps to allow resting places for juvenile fish. The distance smaller rock should be placed away from the boulder should be equal the diameter of the small rock. The combination of boulders, smaller rock and coarse wood replicates some of the elements of a small landslide.

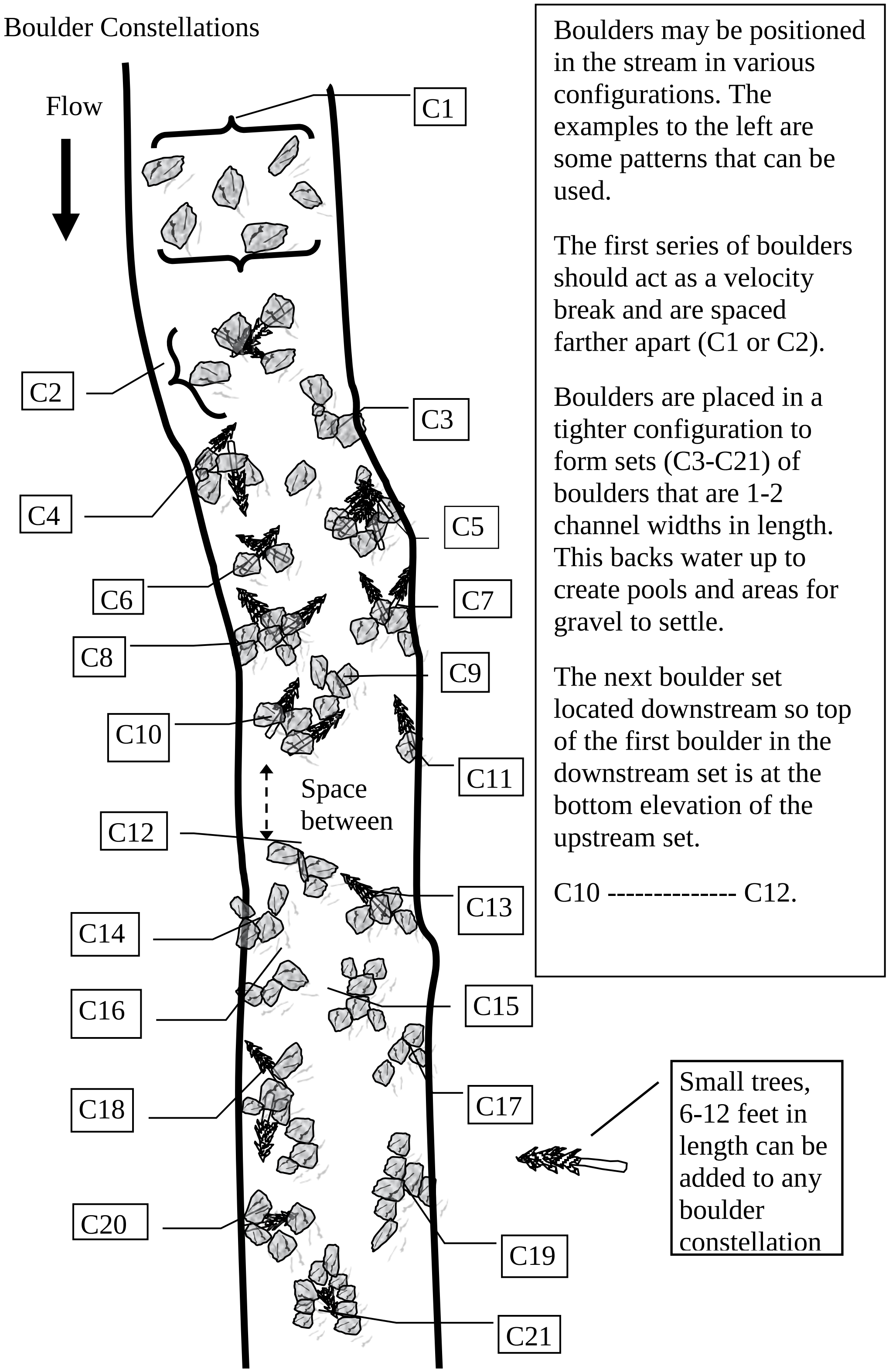


Figure 6- 6. Examples of boulder constellations that can be used to slow the water down to collect gravel. Each constellation may have their orientation changed to meet the site-specific requirements. For clarity of the illustration, the boulder constellations are spaced further apart than what will be used in the habitat restoration project (ODFW, 2010).

Making Boulders More Effective

Boulder clusters capture bed load in two major ways. The first, is physically intercepting the bed load that is sliding or saltating downstream. Saltating is where a bed load material slide along the stream bottom and occasionally being suspended over a short distance and may bounce off of larger material before resting in a stable position. The second way is to reduce the velocity of the water to a point where bed load material cannot be carried.

The greatest accumulation of bed load material occurs when 30 to 60% of the pre-project bankfull area is occupied by boulders or a combination of boulders and wood. For example, if 50% of the pre-project bankfull area is occupied, the 5-year floodplain may become the new bankfull elevation, and the existing 25-year flood elevation may become the new functional 5-year floodplain area. This elevation is important to determine if the new flood elevation may impact infrastructure such as roads or buildings and to determine the amount of winter refuge habitat created. The acceptable percentage of occupied bank full area must be determined on a site-specific evaluation of surrounding land uses, infrastructure, and landowner concerns.

The interception of bed load that is sliding or saltating is illustrated in Figure 6-7 where each structure blocks the direct downstream movement of coble or gravel. Boulder clusters also create low velocity backwater conditions on the upstream side of the structure. Raising the effective bed elevation reduces channel slope, flow velocity, and the stream's ability to transport sediments. Backwatering commonly induces sediment deposition and increases the water surface elevation upstream of the structure at low to moderate flows. At high flows, backwatering effect of the structure is evident provided the structure lies high enough in the channel profile and reduces the channel cross-section. Deposition upstream of a structure is particularly common in moderate to high bed load channels. Sediment deposition upstream of the structure is not as likely for low bed load or incising channels due to limited sediment availability. The upstream extent of backwater depends upon the scale of the structure and the slope of the channel. Backwater effects extend much further on low-gradient streams than on high gradient streams. However, if the structure causes a significant reduction in channel cross-sectional area or a series of structures collectively increase the hydraulic roughness of the channel, backwater effects may be more far reaching. Effects of large-scale backwatering can include increased flood levels and frequency of floodplain inundation, potential change in riparian species composition and distribution in response to changing inundation patterns and water table elevations, and reduced reach transport of sediment. Other effects associated with reduced sediment transport include channel aggradation, channel widening during high flow event and confinement during summer flows, and increased channel meandering.

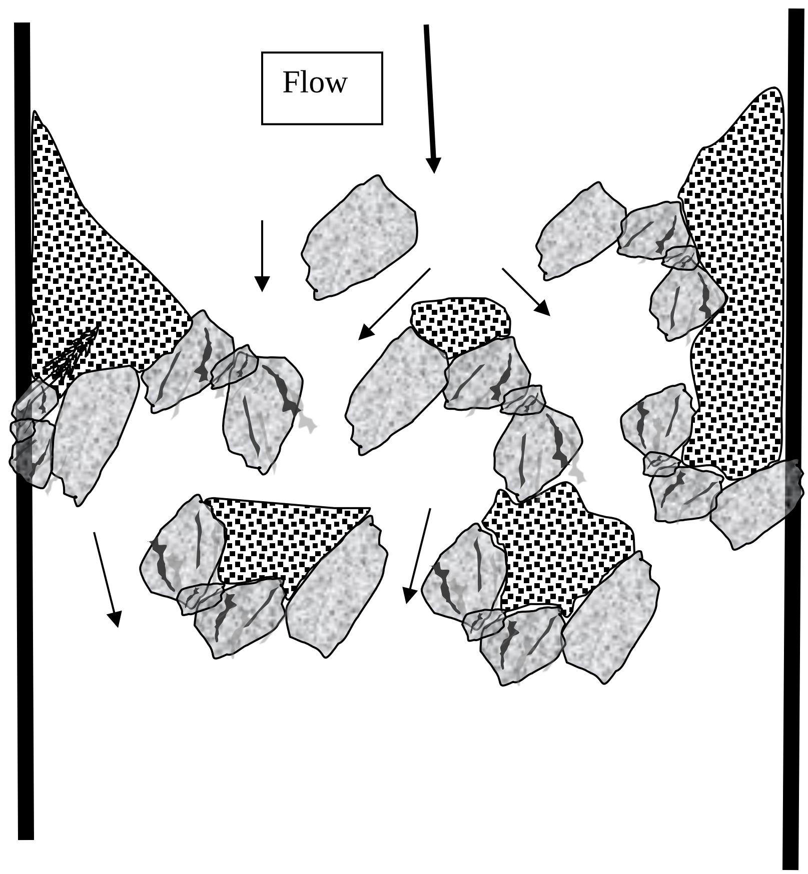


Figure 6- 7. Accumulation of bed load material above boulder constellations with gaps to allow fish passage for all life stages at all flows (ODFW, 2010).

Slide Emulation

Landslides produce a combination of material that is delivered to the stream to provide the components for complex habitat structures. In bedrock-dominated areas the singular use of either wood or boulders may not achieve the desired effect. Unanchored wood can trap gravel but during channel forming events can float allowing the accumulated gravel to be transported downstream. Boulders used as the only material can intercept the gravel but as the water level raises any wood will be carried downstream. Wood can be added to a boulder structure to assist with gravel deposition or to scour pools. The wood can be placed in configurations shown in Figure 6-6 to provide complex lateral pool habitat in the gaps between the boulder constellations or as a full spanning suspension log to increase the deposition of bed load or to scour pools at high flows.

Constructed Riffle Complexes

The constructed riffle comprises three distinct morphologic features including the glide, riffle, and run (NRCS, 2007). These features are designed to provide several critical functions including geomorphic stability and diversity of water depth, substrate, and velocity, thereby increasing habitat complexity (NRCS, 2007). An example of a constructed riffle complex design and drawings can be found within the NRCS Engineer's Design Report for the Shitike Creek Restoration and Salmonid Habitat project (NRCS, 2007).

The glide component of the feature represents the widest design template used in the channel design. The glide is the recovery zone for material scoured out of the upstream pool and is often considered the pool tail-out feature. The glide is an area of spatially reduced shear stress during channel forming flow. It is aggraded and induces deposition of bed materials required for spawning. The glide transitions into the downstream riffle (NRCS, 2007).

Riffles are natural depositional features during high flow but degrade (erode) as stage falls. The opposite occurs in pools where the stream degrades at flood flows and deposits as flood stage recedes. The steep slip face that is observed at low flows near the downstream end of the run is indicative of the degrading nature of riffles observed when sediment transport is reduced on the falling limb of a hydrograph, but the stream is still able to erode the material off the riffle and into the pool. The over-steepened slip face erodes in an upstream direction until exposed larger material creates a stable armor layer and/or the discharge falls to a point where the stream cannot continue to erode it (NRCS, 2007). The design for the example Shitike Creek project was to over-excavate the channel feature approximately 24 inches below finished grade then backfill with 10" minus well graded material as developed through gradation curves. The gradation was augmented with the distributed placement of boulder elements to counteract the potential for riffle failure (NRCS, 2007).

Boulder placement begins near the downstream end of the glide to provide large scale roughness during high flow and hydraulic variability under low flow conditions. Hydraulic effects of the boulder placement include spawning material retention and deposition along the glide face. Boulders placed along the riffle and run provide disruption of average velocity gradients and serve a grade control function for the overall geomorphic unit. Boulder elements would be placed in random patterns that replicate natural stream conditions with particular attention to boulder placement to reinforce the run - pool transitional slip face (NRCS, 2007).

Boulder Vanes

Boulder vanes can be utilized to provide grade control, redirect the channel thalweg, control channel alignment in confined areas or in proximity to infrastructure, alter and maintain the width to depth ratio of the channel, protect an eroding or sensitive streambank, create and maintain a scour pool for fish habitat, concentrate low flow into a deeper, narrower channel to improve fish passage in otherwise flat-bottomed channels, backwater the upstream channel (to increase riffle water depth, provide fish passage over barrier drops, provide water to diversions, or other uses), and encourage sorting of sediment at the pool tailout (Cramer, 2012). Vanes may be oriented in many potential directions relative to flow and the orientation may even change (e.g. zigzag) along their length (Cramer, 2012).

Porous Weirs

Porous weirs are low-profile structures typically comprised of boulders that span the width of the channel (Cramer, 2012). Collectively, the boulders within a porous weir redirect flow by concentrating water between individual rocks. Porous weirs are typically arranged to form an upstream-pointing arch in plan view, with their lowest point located at the apex of the arch (Cramer, 2012). Porous weirs are designed with spaces between boulders that allow water, sediment, fish, and other aquatic organisms to move through the structure (Cramer, 2012). Porous weirs are used primarily for flow redirection and to increase channel complexity through scour and sorting of sediment.

6.2.c. Floodplain Re-connection, Side Channel and Off-Channel Development

Floodplain and Channel Migration Zone Restoration

This section describes activities relating to floodplain and channel migration zone reconnection for the purpose of habitat restoration. These activities include the removal or modification of features that confine the active channel, limit floodplain inundation, or inhibit channel planform adjustment. Examples include levee removal or setback, removal of bank armoring, and the restoration of floodplain topography and vegetation conditions. This technique focuses on passive, process-based approaches that remove features that confine channels and encroach on floodplains (Cramer, 2012). A thorough understanding of fluvial geomorphology is essential for floodplain restoration projects. The following is a brief summary of techniques. Cramer (2012) is a good reference for detailed project development.

Removal of Floodplain Encroachment Features

Typical features that encroach on floodplains and channel migration zones include roads, houses, buildings, and utilities. Such features may or may not include levees and bank armoring but may nevertheless impact floodplain and channel migration zones processes and off-channel habitat. In some cases, removal of these features will restore floodplain inundation rates, restore natural channel migration, and allow for the development of floodplain channels that are important for off-channel fish habitat (Cramer, 2012). Relocation or setback may be an option for roads and utility corridors that confine or otherwise impact floodplains. Removal of floodplain features is often not possible due to human needs and/or could be cost prohibitive.

Modification or Removal of Bank Armoring

Where feasible, removing bank armoring allows for more deformable channel boundary conditions and restores natural rates of erosion and planform adjustment. This technique allows for more natural rates of bank erosion and channel migration over the long-term (Cramer, 2012). When removing bank armoring, it is critical to consider post-project channel boundary conditions and stability, which will likely be considerably different than natural, pre-armoring conditions at the site (Cramer, 2012). Most sites subjected to bank armoring have been cleared of vegetation, armored using large rocks or other structures and backfilled with soil. Channel conditions have likely adjusted to bank armoring including deepening and coarsening of the bed. These altered conditions will impact post-project stability and must be considered in design (Cramer, 2012).

It is typically necessary to provide some interim stability to the restored bank so that dramatic instability does not impair habitat or cause unintended consequences to downstream or upstream reaches (i.e. erosion and flooding) (Cramer, 2012). Interim stability is provided until a time when replanted riparian vegetation has matured and can eventually provide long-term natural stability. Approaches include reconstructing banks using soil encapsulated fabric lifts, large wood jams, or other bio-engineering techniques that combine vegetative plantings with soil stabilization measures (Cramer, 2012).

Restoration of Floodplain Topography and Vegetation

Restoring floodplain topography and vegetation may be desirable in order to restore natural flood flow pathways, set the template for future channel planform adjustment, enhance off-channel/floodplain habitat, increase floodplain sediment storage, and restore nutrient exchange pathways (Cramer, 2012). Restoration of topography may include the creation of features found in natural, connected floodplains including swales, natural levees, off-channel features, flood overflow channel depressions, and wetlands (Cramer, 2012). Planting of native vegetation communities is typically conducted to benefit overbank hydraulic conditions (roughness), to provide a source for future wood recruitment, and to improve terrestrial and aquatic habitat.

One of the primary reasons for restoring topography and vegetation is to manage for appropriate floodplain roughness (Cramer, 2012). This is because many developed floodplains have been cleared and graded and natural roughness features have been removed. This creates a risk of significant instability and avulsion potential once floodwaters are reintroduced to the site. A floodplain and channel migration assessment may be necessary for evaluating the risk of avulsion. If flow velocities over the floodplain are high enough to entrain floodplain material and there is low roughness due to prior land-use, then the potential for channel avulsion may be high. Unless avulsion is an acceptable and anticipated outcome, precautions to limit avulsion potential may be required. Examples placing logs or river log structures in the floodplain to increase roughness, and planting dense vegetation within the floodplain (may take years until roughness or stability is provided by vegetation) (Cramer, 2012).

It may be advantageous to implement measures within the floodplain and channel migration zone prior to reconnection activities. For example, converting an agricultural field to a floodplain may require placing stable, properly ballasted wood or planting and managing floodplain vegetation for some period of time in order to provide functional roughness components prior to reconnection (Cramer, 2012).

In some cases, aggressive modifications to floodplain topography can be conducted in order to allow the stream itself to make beneficial planform adjustments in a passive approach during floods (Cramer, 2012). An example is the excavation of preferential channel flow paths in the restored floodplain area that the main channel or side channel will eventually occupy, in effect setting the template for future planform adjustment. This technique is appropriate for systems that have been straightened and confined and where floodplain areas that were historically accessible for channel migration have been filled and graded. This approach can bring about beneficial changes more rapidly than simple removal of confinement features, and it also requires less in-water work for construction; however, it also carries greater uncertainty and requires more analysis to manage for risk.

Despite the potential benefits, restoration of floodplain topographic features may be inappropriate in some situations. Florsheim and Mount (2002) as referenced in Cramer (2012) documented floodplain topography changes after intentional levee breaches along the Lower Cosumnes River in California, and found that, in this case, excavation of floodplain ponds and other depressional features actually trapped incoming sediment and limited the natural development of floodplain topography.

Floodplain Lowering and Raising the Channel Bed

Floodplain lowering and/or raising the channel bed can be used for areas where floodplains are disconnected as a result of floodplain fill or channel incision (Cramer, 2012). This reconnection technique requires a thorough understanding of watershed inputs, channel processes, the legacy of past land-use, and future trends in channel geometry. If the underlying causes of channel incision are not addressed, then applying this technique may involve a significant risk of failure or may require continual maintenance.

Raising the channel bed can be used to increase the frequency and extent of floodplain inundation. Raising the channel can either be conducted using channel profile adjustment structures (aka. grade control) that protrude from the channel and are designed to aggrade sediment over time, or can be conducted using a combination of structures and fill to bring the channel up to the desired grade (Cramer, 2012). If hydrologic conditions are the cause of the problem and are not addressed, persistent instability may continue post-project and may once again cause floodplain disconnection through channel widening or re-incision. This technique is most successful where incision is related to local, reach-scale impacts such as channelization, removal of LW, removal of vegetation, or instream gravel mining.

Floodplain lowering is another means for increasing the frequency and extent of floodplain inundation. This technique includes the excavation and removal of floodplain material in order to lower floodplain elevations (Cramer, 2012). Floodplain lowering is frequently used when raising the channel bed is too costly, uncertain, or otherwise inappropriate, and is usually not cost-effective on large stream systems with extensive floodplains. Floodplain lowering may be appropriate for incised channels that have already progressed through some degree of incised channel evolution and associated widening and incipient floodplain development. This technique may also be useful for increasing the amount of available storage for surface water and sediment during overbank floods.

Side Channel and Off-Channel Habitat

There are three basic types of side channel restoration that are connected and associated with mainstem river channels covered in Cramer (2012) which include:

- Creation – the creation of new side channel habitats.
- Reconnection –the hydrologic reconnection of existing side channel habitat that has been disconnected through human actions such as levee construction, channel filling, or channel incision.
- Enhancement – the enhancement of aquatic habitat within an existing side channel.

Numerous types of side channel and off-channel habitats exist, each with unique attributes depending on the biophysical setting and the processes that create and maintain them. Figure 6-8 is a visual display with examples of potential side channel projects. Side channels and off-channels are variously categorized and may include habitat types such as sloughs, oxbow lakes, wall-based channels, floodplain depressions, or chute cutoffs (Cramer, 2012). The primary distinction is their separation from the main channel and may have only seasonal or high water connections. Restrictions and constraints such as levees, dikes, bank protection, and channelization, often isolate side channel habitats from the main stem and prevent or limit the channel from migrating in a manner that can create new side channels (Cramer, 2012). As a result, this valuable habitat is frequently lost or becomes inaccessible for fish.

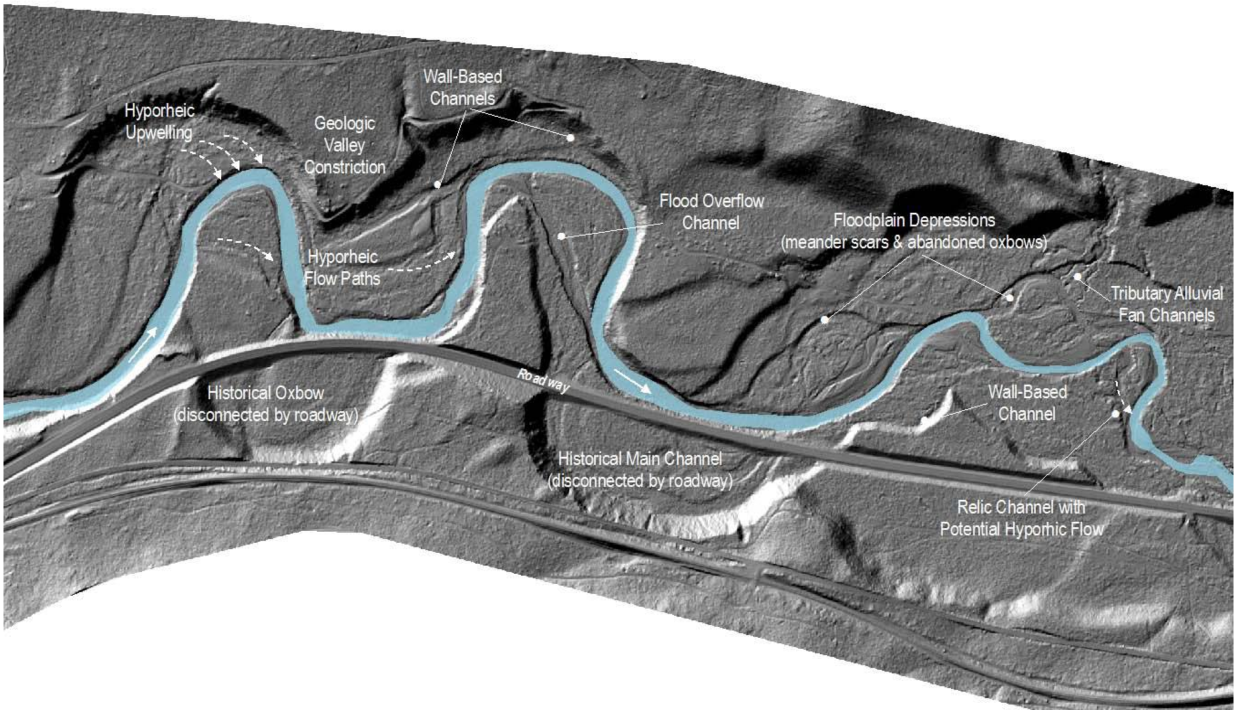


Figure 6- 8. Hill shaded relief map showing geomorphic features that may indicate the potential for side channel projects (Cramer, 2012).

Ideally, side channels should be created where they will be sustained through natural processes. This includes allowing for natural channel dynamics including avulsions and channel migration, which may eventually overtake the project site (Cramer, 2012). Though this occurrence is frequently viewed as a failure, if new side channel habitat is formed as a consequence, the habitat is self-sustaining and habitat objectives may nevertheless be achieved. In many situations, however, active channel shifting may not be tolerable, but side channel projects may nevertheless provide important habitat benefits. Examples include areas where infrastructure or landowner constraints limit the ability for channel shifting.

The supply of water to side channels may include surface water from the main channel, hyporheic flow, groundwater flow from upslope areas (i.e. springs), or tributary flow (Cramer, 2012). Many projects will include a combination of these sources. A channel may have an overflow source from the river during high flow seasons, a groundwater source during low flow seasons, and be supplemented with flow from a wall-based source.

One of the major concerns with intermittent side channels is fish stranding, which may occur if the side channel loses surface connectivity with the mainstem but fish remain within the channel in isolated pools (Cramer, 2012). This condition increases the risk of fish mortality through temperature impacts, predation, water quality, and potential eventual desiccation. Fish stranding risk can be reduced by 1) ensuring that target fish species will have exited the site by the time the surface connection is lost with the mainstem or 2) designing for year-round side channel connectivity with the mainstem. The impact of flow diversion on the mainstem will need to be considered as part of project planning and design. Diverting flows from the mainstem to the side channel can have potential impacts on fish passage, stream temperature, and habitat availability.

6.2.d. Bank Stabilization

Unless otherwise referenced the majority of the bank stabilization section was derived from the Streambank Revegetation and Protection: A Guide for Alaska (ADFG, 2005). An excellent reference for bank stabilization techniques is the Integrated Streambank Protection Guidelines (Washington State Aquatic Habitat Guidelines Program, 2002).

Bundles (Fascines)

Bundles (fascines) are a group of dormant branches bound together to create a log-like structure that will root, grow and provide plant cover quickly (Figure 6-9). The bundle is used to revegetate and stabilize slopes, break-up slope length, and/or provide a transition from one revegetation technique to another (e.g., a brush mat to a live siltation). Bundles create small terraces that encourage native plant seed collection and growth.

- Collection, storage and hand planting information are described in the Dormant Cuttings section of Riparian Planting.
- Tie together several dormant branches 1/2 to 2 inches in diameter and at least 3 to 4 feet long. Orient the cut ends of the branches in opposite directions to create a bundle with a uniform diameter. Typically, bundles are 4 or more inches in diameter and can be constructed to any length by overlapping branches as the bundle is formed and tying it tightly together with biodegradable twine, approximately every 1 to 2 feet.
- Use a shovel or pick axe to dig a trench that slopes diagonally down and back into the hill. Install bundles by placing them horizontally in a shallow trench, burying approximately 3/4 the depth of the bundle diameter with soil, water and tamp in place to remove air pockets.
- Drive at least two 18-inch wooden stakes or live willow stakes through the bundle to secure it firmly into the trench. If the slope is steep and the erosion potential is high, drive additional stakes downhill and immediately in front of the bundle. Do not cover the bundle entirely so it will be able to grow.
- Place bundles end-to-end or slightly overlapping to form a continuous planting that should follow the contour of the slope. They can be planted in single or multiple rows or in a staggered pattern that reduces the surface erosion potential of a site. Fascines may also be placed in a "smile" configuration, with the fascine ends turned upslope. Location and spacing of the bundles will vary with site conditions and the overall revegetation design.

Advantages:

- In low velocity systems, this technique provides good density of vegetation and root matter
- Breaks up slope length
- Can be cost effective

- Easy to construct and install
- Provides terraced area for soil and seeds to settle
- Provides fish and wildlife habitat

Disadvantages:

- Requires a lot of willow
- May require additional toe-of-slope and bank stabilization using techniques listed in this guide

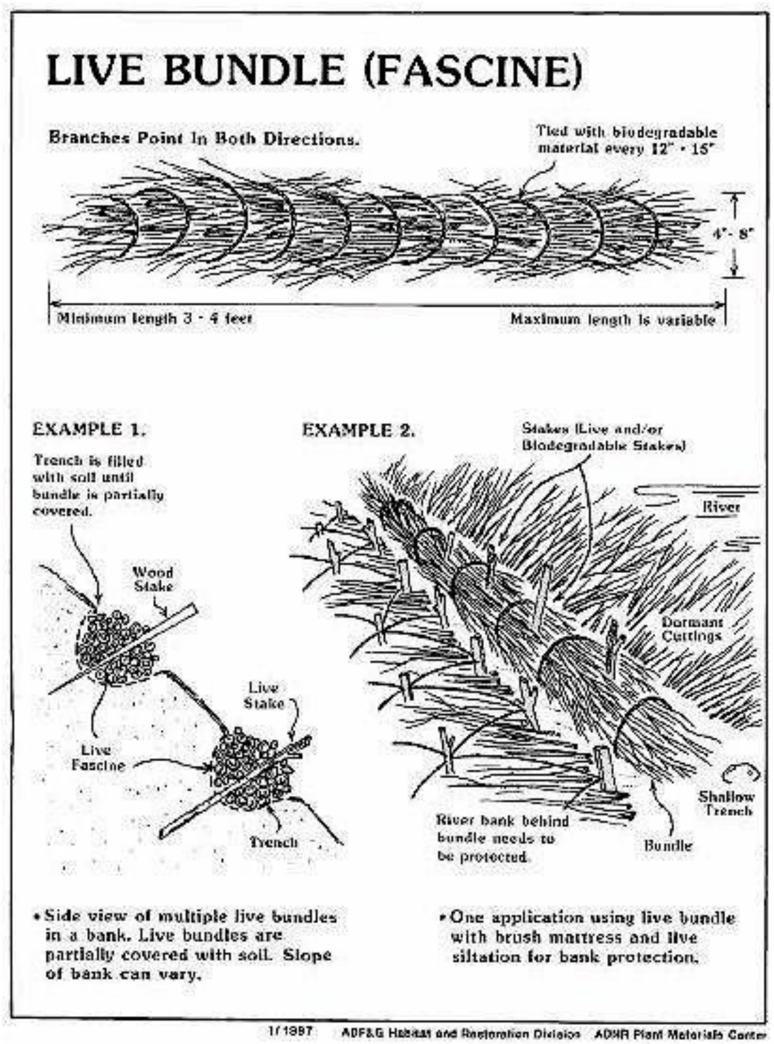


Figure 6- 9. Examples of live bundle (fascine) techniques (ADFG, 2005).

Live Staking

Live staking is a simple technique that installs a dormant cutting directly into the ground (Figure 6-10). This technique is often utilized where single stem plantings will provide adequate plant cover, slope stability and fish habitat. Live staking should be combined with other revegetation techniques; these may include anchoring bundles, brush mats and erosion control fabric.

- Prepare several live stakes from one dormant cutting. Cut stakes 10 to 18 inches long, 1/2 to 2 inches in diameter (slightly larger diameter cuttings will also work). Discard flower buds (pussy willows). Flower buds typically occur at the top 2/3 of a branch that was produced during the past growing season. At least one or two leaf buds that are smaller than flower buds must be present near the top of each live stake.
- Select planting sites carefully since live stakes require moist soils. The bottom 6 inches needs to be in permanently moist soils. If planted on drier slopes, survivability will decrease. Watering could increase survival and promote plant growth. Occasional deep watering is more effective and encourages deeper rooting than frequent light watering. Water during the first 6 weeks after planting if in non-permanently moist soil.
- Use rebar, 3/4 inch or less in diameter, to create a planting hole for longer stakes, particularly when planting in compact and gravelly soils. A shovel or hydraulic drill may also be used. Tightly pack the soil around the stake so that no air pockets remain.
- Plant stakes upright 1 to 3 feet on center. Stakes should be planted as vertically as possible, placing at least 3/4 of the stake below ground so that only one or two leaf buds are left exposed above the ground. The intent is to maximize the surface area for rooting so a good root system can develop and support a healthy shoot system. If more than one or two buds, 1/4 of the stake, or 4 inches of the live stake is extending above the soil surface, trim the stake.
- Water to help remove air pockets and increase contact between the soil and surface of the live stake. Moist soil is needed during the period the live stake is rooting and becoming established, at least 4 to 6 weeks after planting. Topsoil is not required. Survival rates for drier sites may be increased if larger cuttings are used along with increased watering.

Advantages:

- Inexpensive
- Not labor intensive
- Low tech
- May plant in high densities

Disadvantages:

- Low survival compared with other revegetation techniques discussed
- Should be used in conjunction with other revegetation techniques
- Ease of planting is dependent on soil type and site condition
- Should only be used at sites with moist soils, or prepare to water extensively

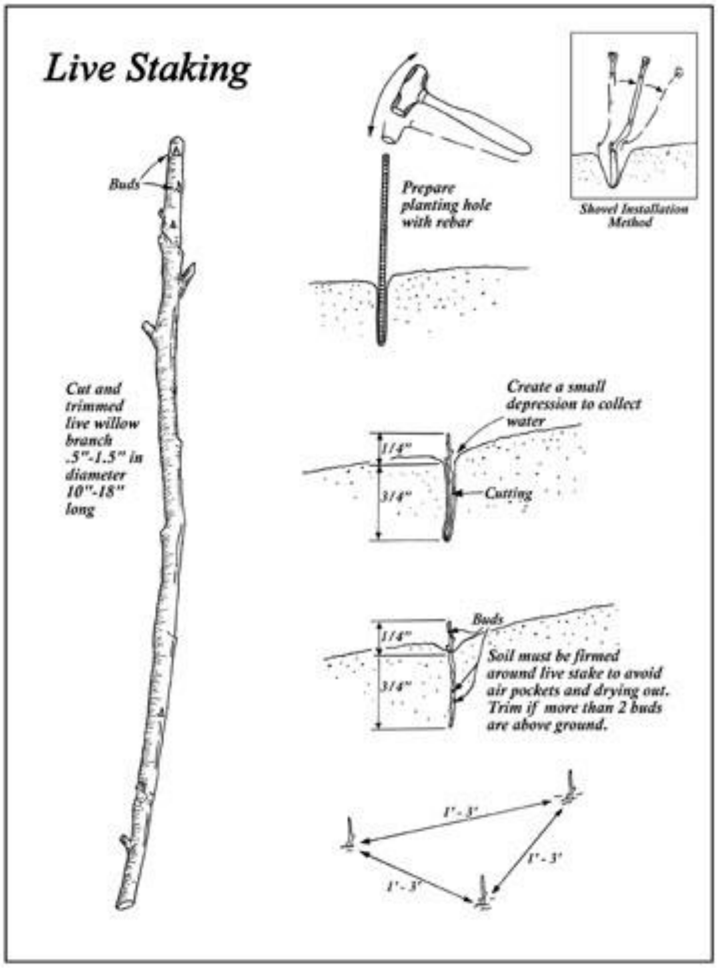


Figure 6- 10. Live staking technique (ADFG, 2005).

Live Siltation

Live siltation is a revegetation technique used to secure the toe of a slope, trap sediment and create fish rearing habitat (Figure 6-11). This technique may be installed behind other toe-of-slope protection. The practice can be constructed as a living brushy system at the water's edge. This technique is particularly valuable for providing immediate cover and fish habitat while other revegetation plantings become established.

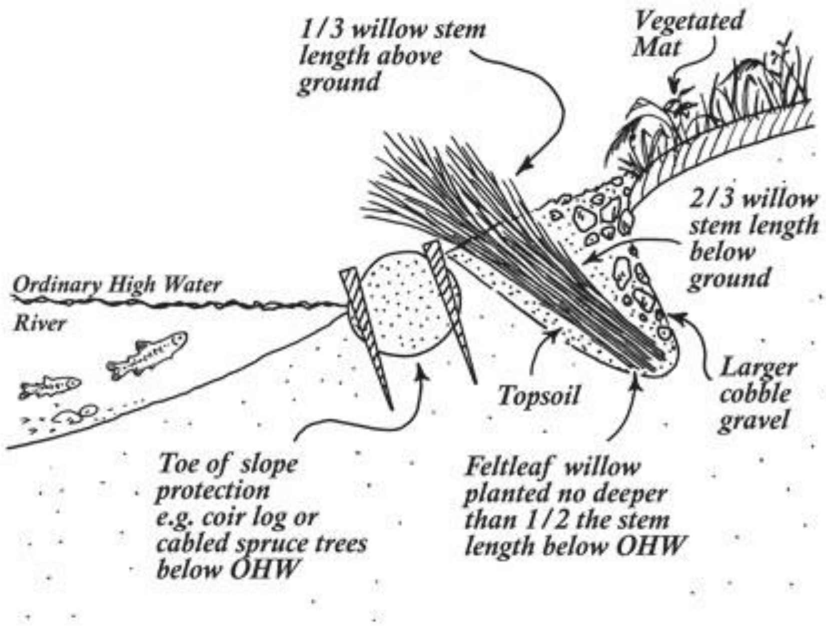


Figure 6- 11. Live siltation technique (ADFG, 2005).

- Collection, storage and planting information are described in the Dormant Cuttings section of Riparian Planting. The dormant branches need to be a minimum of 3 feet long with side branches still attached.
- Construct a v-shaped trench above the ordinary high water (OHW) level, with hand tools or a backhoe. Excavate a trench so that it parallels the toe of the streambank and is approximately 2 feet deep. Lay a thick layer of willow branches (8"-10" before compaction) in the trench so that 1/3 of the length of the branches is above the trench and the branches angle out toward the stream. Place a minimum of 40 willow branches per yard in the trench. Of the 2/3 buried willow, not more than 1/2 should fall in permanently moist soil.
- Backfill over the branches with a gravel/soil mix (Figure 6-12) and secure the top surface with large washed gravel and/or bundles (see Bundles and Coir Logs sections). Both the upstream and downstream ends of the live siltation construction need to transition smoothly into a stable streambank to reduce the potential for the technique to wash out. More than one row of live siltation can be installed.

Figure 6- 12. Live siltation during construction (ADFG, 2005).

Advantages:

- Provides good fish habitat
- Provides bank stability in low velocity areas
- Provides good riparian vegetation

Disadvantages:

- Requires shallow water and slope
- Requires relatively low velocity
- Critical to know OHW (ordinary high water)

Brush Matting

Brush matting is a revegetation technique that provides a protective vegetative covering to a slope as soon as it is installed. A brush mat can be constructed with dormant branches that will root and grow and is often combined with other revegetation and/or protection techniques which are used to secure the toe of the slope including root wads, live siltation, bundles, coir logs, brush layering, and conifer tree revetments (Figures 6-13 through 6-16).

A brush mat is recommended over an erosion control mat without vegetation because it provides erosion control while also providing quality fish and wildlife habitat. The brush mat may grow and provide plant cover, and the small pockets created by the overlapping branches will trap native seeds and provide an environment for germination and growth. During high water, a brush mat may trap sediments and eventually the plant growth on the stabilized streambank will provide fish habitat. If the original bank is denuded of vegetation and the soil is compacted, be sure to scarify the bank and deposit soil before installing brush mat. Additional toe-of-slope protection may be necessary.

Figure 6- 13. Brush mat and live siltation constructed in Alaska in 1994. Bundles were used to provide a transition between the two techniques (ADFG, 2005).

Figure 6- 14. Live siltation and brush layering at the Little Susitna River, Alaska (ADFG, 2005).

Figure 6- 15. A brush mat - note the crisscross pattern of the jute used to anchor the mat to the bank (ADFG, 2005).

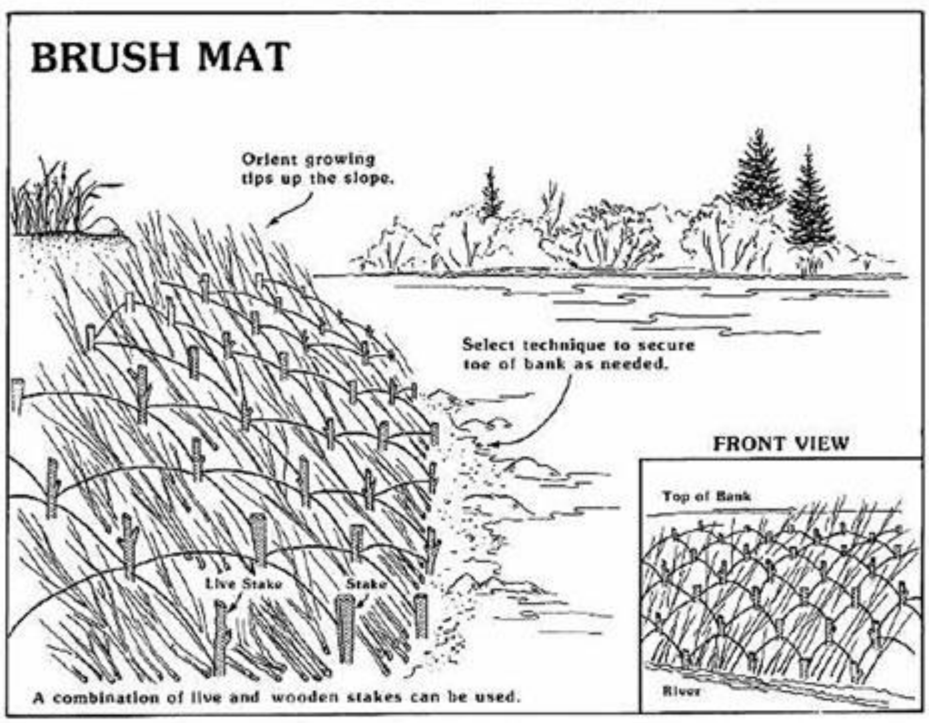


Figure 6- 16. Example of brush mat stabilization technique (ADFG, 2005).

Collection, storage and planting information for a living brush mat are described in the Dormant Cuttings section in Riparian Planting. Brush mats require large quantities of plant materials. The availability of plant material should be carefully evaluated before including this technique in a revegetation design.

- Install branches flat on the bank and perpendicular to the stream with branches slightly crisscrossed (Figure 6-15 and 6-16). The large end of the branch is placed at the toe of the slope. Add branches until the soil surface below the branches is covered. Brush mats can be installed over rooted plants and live stakes that are planted on a slope.
- Stake the mat in place with stakes or live stakes and biodegradable twine or rope. Place stakes on 3-foot centers, attach twine around each stake to form a criss-cross pattern, and then drive the stakes into the substrate as deeply as possible pulling the branches tightly against the soil (see Live Staking section). Add a small amount of soil over the mat so that the lowest layer of branches is partially buried to encourage rooting. Water brush mat lightly to compress the added soil; then add more soil if necessary. The completed compressed mat will be approximately 3-4 inches thick. If high water occurs before the brush mat becomes established, the topsoil on the lower portions of the mat may wash away. A light seeding of native grass may help prevent/reduce the loss of topsoil.

Advantages:

- Provides good plant coverage and erosion control
- Promotes good soil stability
- No geotextile or metal left in bank

Disadvantages:

- Labor intensive and may be technically challenging
- Requires a large quantity of plant material

Consult with a streambank revegetation specialist before installation of any revegetation or protection technique is necessary to gain site specific information.

Hedge-Brush Layering

Brush layering is a revegetation technique, which combines layers of dormant or rooted cuttings (see Dormant Cuttings in Riparian Planting section) with soil to revegetate and stabilize both streambanks and slopes (Figure 6-17 and Figure 6-18). A larger variety of plant species may be utilized with a hedge brush layer (dormant cuttings and rooted plants) than with a simple brush layer (dormant cuttings). Rooted plants of species that do not root readily, such as alder, can be included in the plant layer. A mixture of species may allow the revegetation project to blend with existing vegetation. Branches are placed on an angled bench that follows the contour of the slope and provides reinforcement to the soil. Steep slopes and streambanks are better stabilized when a biodegradable revegetation fabric is used to hold the reinforced soil lifts in place between the plant layers. Plant material placed using brush layering provides fish habitat and nutrients to the adjacent water body.

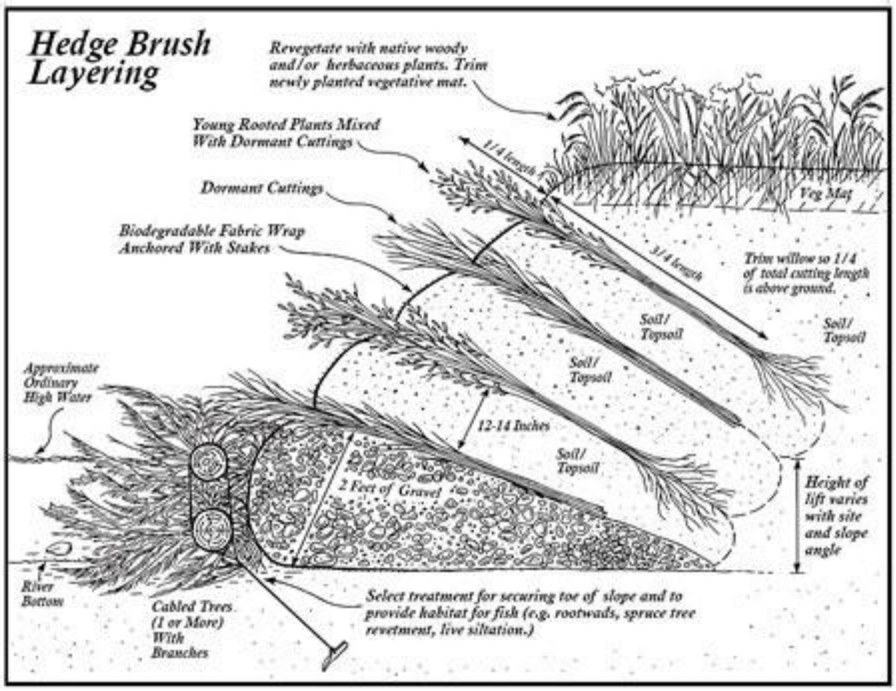


Figure 6- 17. Cross-section depicting hedge brush layering (ADFG, 2005).

Figure 6- 18. Installation of brush layering, Little Susitna River, Alaska (Youth Restoration Corp from ADFG, 2005).

- Collection, storage and planting information are described in the Dormant Cuttings section of Riparian Planting. Different species of woody cuttings that root easily (see Plant Species Selection List, Shrubs and Trees) can be mixed in the layers (Figure 6-19); rooted plants can also be added to create a hedge-brush layer. Rooted plants may be planted throughout the growing season from spring through early fall. Dormant plants, if collected in the spring, should be planted late winter/early spring.
- Choose a technique such as root wads, live siltation, coir logs, or cabled conifer tree revetments to secure the toe of the slope (Figure 6-20). Consult streambank revegetation professionals and evaluate site conditions to determine the treatment of the toe-of-slope. Perform all construction activities during periods of dry riverbed; dewater area, or isolate the work area. Along a water body, the first brush layer typically occurs at the OHW (ordinary high water) level, often identified by the line of growing vegetation (plus other factors).
- Prepare a bench, which corresponds to the bank depth necessary to stabilize the slope, either through excavation or building up the slope, so that it angles slightly down and into the bank (Figure 6-18). It is important to note the upstream and downstream riparian species and slope height and angle when designing a brush layer project. Specifications should represent the local native environment as much as possible. If the surrounding area has been greatly impacted, observation further upstream and downstream may be necessary. Place fifteen dormant branches on the bench per foot or ten rooted cuttings per foot, slightly crisscrossed (see Hedge Brush Layering/Brush Layering section). A mixture of dormant cuttings and rooted plants may be used. The cut or rooted ends are placed into the slope with the tips extending beyond the edge of the bench **no more than 1/4 of the total branch length** (Figure 6-19). Place 2 to 4 inches of soil on top of the branches, water and tamp into place.
- The reinforced soil lift is placed directly on top of the brush layer, pulling the next step back according to the designed bank angle (Figure 6-20). Two revegetation fabrics are used in reinforced soil lifts to keep soil in place when a brush layer is installed on steep slopes and streambanks. The first fabric layer, a fine mesh fabric (example: Bon Terra's® ENC2, North American Green's C125 BN, or equivalent) is placed inside the larger mesh fabric (example: Bon Terra's® CF7, North American Green's CCM-700, or equivalent). Next, 12-14 inches of soil-topsoil mix is placed on top of the fabric, watered, compressed and 2-3 feet of fabric is rolled over the top and secured in place with wooden stakes. Follow this step by another layer of dormant cuttings/rooted plants.
- Repeat the branch, topsoil, wrapped soil/topsoil mix layering sequence until the desired bank height is achieved (Figure 6-21). Trim plants back to 1/4 of the planting above ground, 3/4 of the planting below ground. A vegetation mat may be placed on the top layer of the bank after the last brush layer is installed and overtopped with soil. The vegetative mat should be harvested and installed according to consultation with a revegatation specialist. The shoots should be cut back by 1/3 to compensate for root loss and to encourage new root growth.
- Higher density plantings are needed for more erosive sites and if the diameter of the plant material is small. Sites with a shallow slope and low erosion potential can have wider vegetation spacing than sites with a steep slope and higher erosion potential. This technique can be easily mechanized, layer-by-layer, if it is installed during construction of a fill slope. On cut slopes and existing banks each layer must be excavated.

Figure 6- 19. Brushlayer installation prior to trimming, Centennial Park, Kenai River, Alaska (ADFG, 2005).

Figure 6- 20. Rootwad and brush layering bank stabilization, Centennial Park, Kenai River, Alaska (ADFG, 2005).

Advantages:

- Prevents soil erosion and stabilizes bank
- Provides fish habitat and native vegetation
- Reestablishes healthy riparian zone functions
- May be used in higher velocity systems, dependent on toe-of-slope protection
- High success rate
- No permanent geotextile fabrics or metal left in bank

Disadvantages:

- Relatively expensive
- More technologically challenging, requires expertise
- May require heavy machinery
- Requires isolated work area to prevent water body siltation
- Very stable, dependent on toe-of-slope stabilization
- May require significant training

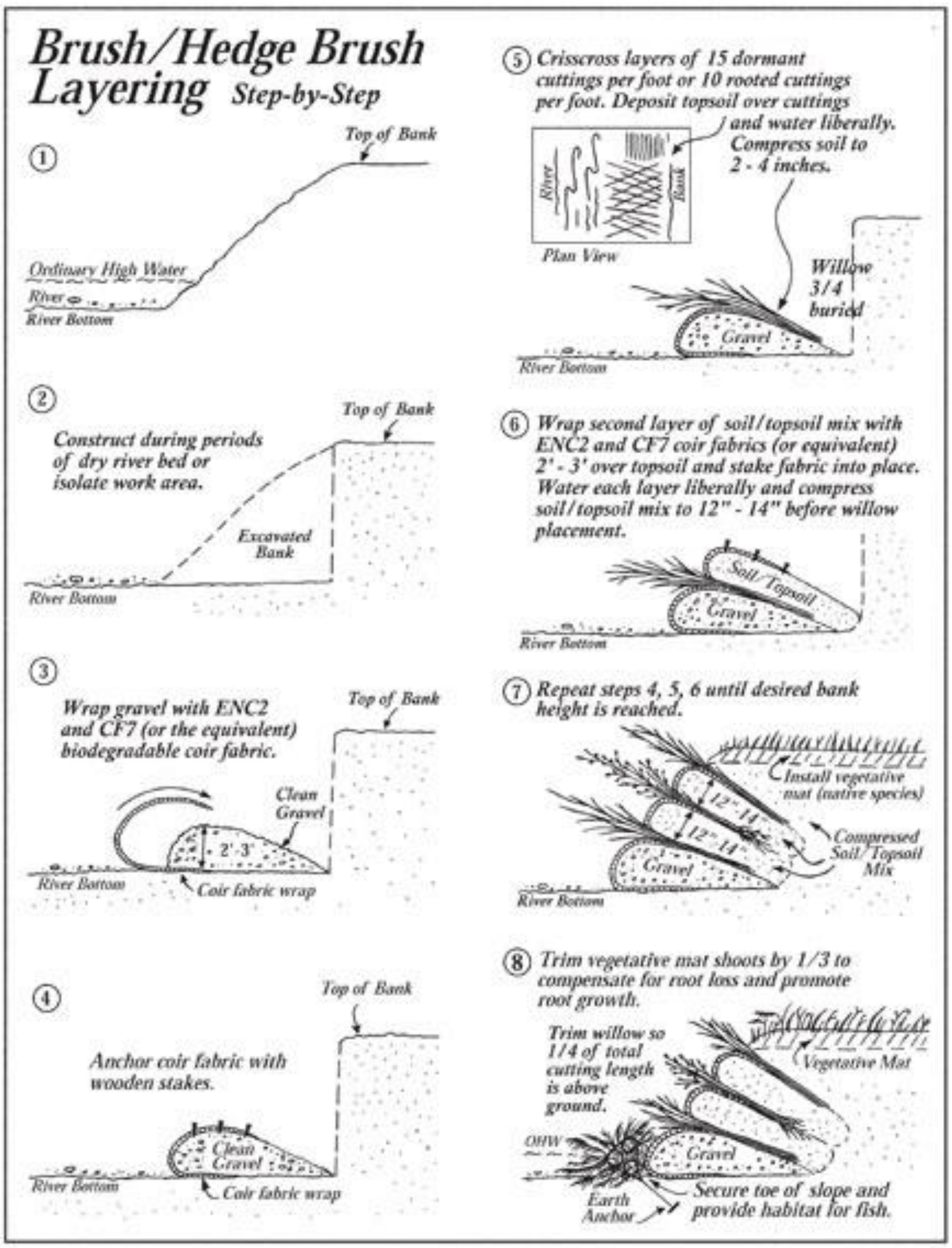


Figure 6- 21. Step-by-step guide to brush layering (ADFG, 2005).

Vegetated Cribbing

Vegetated cribbing is a technique reserved for use at sites where other revegetation techniques may not provide sufficient protection from erosion.

This technique combines layers of reinforced soil lifts and plant material similar to brush layering with the addition of a protective cribbing (see Figures 6-22 through 6-24). Untreated timbers are notched and keyed into each other to create a crib-like structure. Cross-timbers are periodically installed to increase stability.

Layers of cribbing can be added to reach desired height of bank. The layers can be built vertically or stepped back into the slope with deep or shallow steps. Exposed soil should be seeded to protect from erosion.

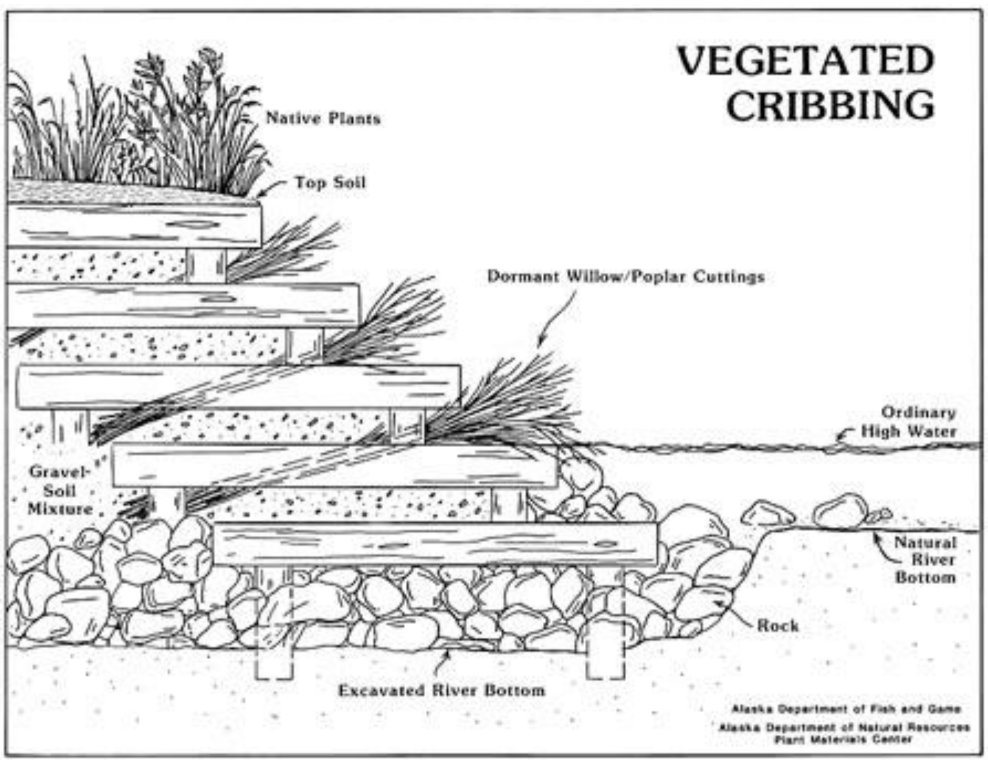


Figure 6- 22. Vegetated cribbing technique (ADFG, 2005).

Advantages:

- Stable
- Prevents soil erosion of bank
- May provide some fish habitat, may be used in higher velocity situations

Disadvantages:

- Very expensive
- Technically challenging
- Requires large machinery

Figure 6- 23. Vegetated cribbing project under construction. Note cross timbers. Project located on the Kenai River, Alaska (ADFG, 2005).

Figure 6- 24. Vegetated cribbing three weeks after installation (ADFG, 2005).

Grass Rolls

Grass rolls are often used to revegetate lake shores and streambanks where grasses and grass-like plants have been the primary vegetation type and where seeding is impractical due to fluctuating water levels (Figure 6-25). Clumps of grass sod are placed tightly together, side by side with shoots pointing up, in a sausage like structure and held together with biodegradable fabric and twine. The roll is then anchored in place (Figure 6-26). This technique reintroduces herbaceous vegetation to a site while simultaneously providing some structural stability. Ultimately, the sod will form a dense root system along the streambank and provide structural protection to the site. When the grasses go dormant at the end of each growing season, their leaves hang over the streambank and provide rearing habitat for fish.

- Construct a grass roll by laying out a length of the biodegradable fabric; place clumps of sod tightly together in the middle of the fabric (Figure 6-27). Bluejoint reedgrass (*Calamagrostis Canadensis*) is the primary grass used for this technique and should be collected from sites away from streambanks. Beach wildrye (*Elymus mollis)* has also been used for streambank plantings, and although it produces a strong rhizome it does not form the dense sod characteristic of Bluejoint reedgrass. Beach wildrye also is suitable for brackish water.
- Wrap the sides of the biodegradable fabric over the sod clumps to make a sausage-like roll. Tie the roll every few inches with twine. Cut holes in the biodegradable fabric wrap to expose the sod shoots. Try to create the grass roll on-site so that the length of the roll(s) matches the length of the area being planted. (Figure 6-27)

Figure 6- 25. Grass roll installation, mouth of Willow Creek, Alaska (ADFG, 2005).

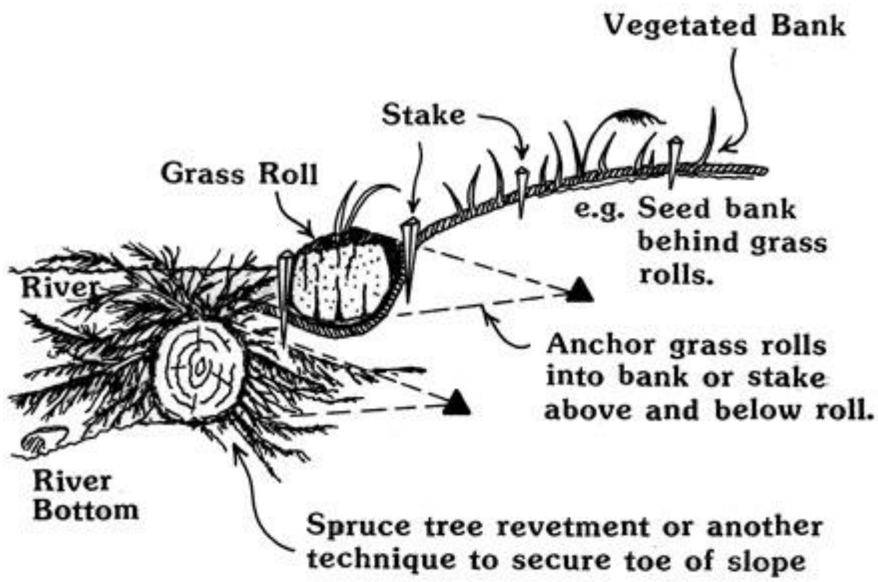


Figure 6- 26. Toe slope stabilizing technique for use with grass rolls (ADFG, 2005).

- Dig a shallow trench in which to install the sod roll along the ordinary high water (OHW) level after the toe of the slope has been protected. Grass rolls may also be constructed on-site in trench using transferred sod. Anchor the grass roll securely into the bank. Earth anchors will be required for installations along streams and rivers. Stakes may be adequate for anchoring a grass roll in low-energy environments such as protected lakeshores (Figure 6-28). Revegetate adjacent areas, if necessary. Both the upstream and downstream ends of the grass roll need to transition smoothly into a stable streambank, undisturbed vegetation, or other revegetation technique.
- Grass rolls can also be used for wetland revegetation. Several sedge species are suitable for this application; they include for freshwater- *Carex aquatilis*, *C. saxatilis*, and for brackish water- *C. Lyngbyaei*.
- Grasses and sedges are particularly sensitive to foot traffic and should be protected by elevated walkways or planted in areas with restricted access to encourage survival.

Advantages:

- Inexpensive
- Uses simple material requiring little mechanized work
- Little training required
- Reestablishes natural condition
- High survivability
- Best around lakes and low velocity areas

- Provides erosion control

Disadvantages:

- Not recommended for high velocity environments
- Requires protection from trampling

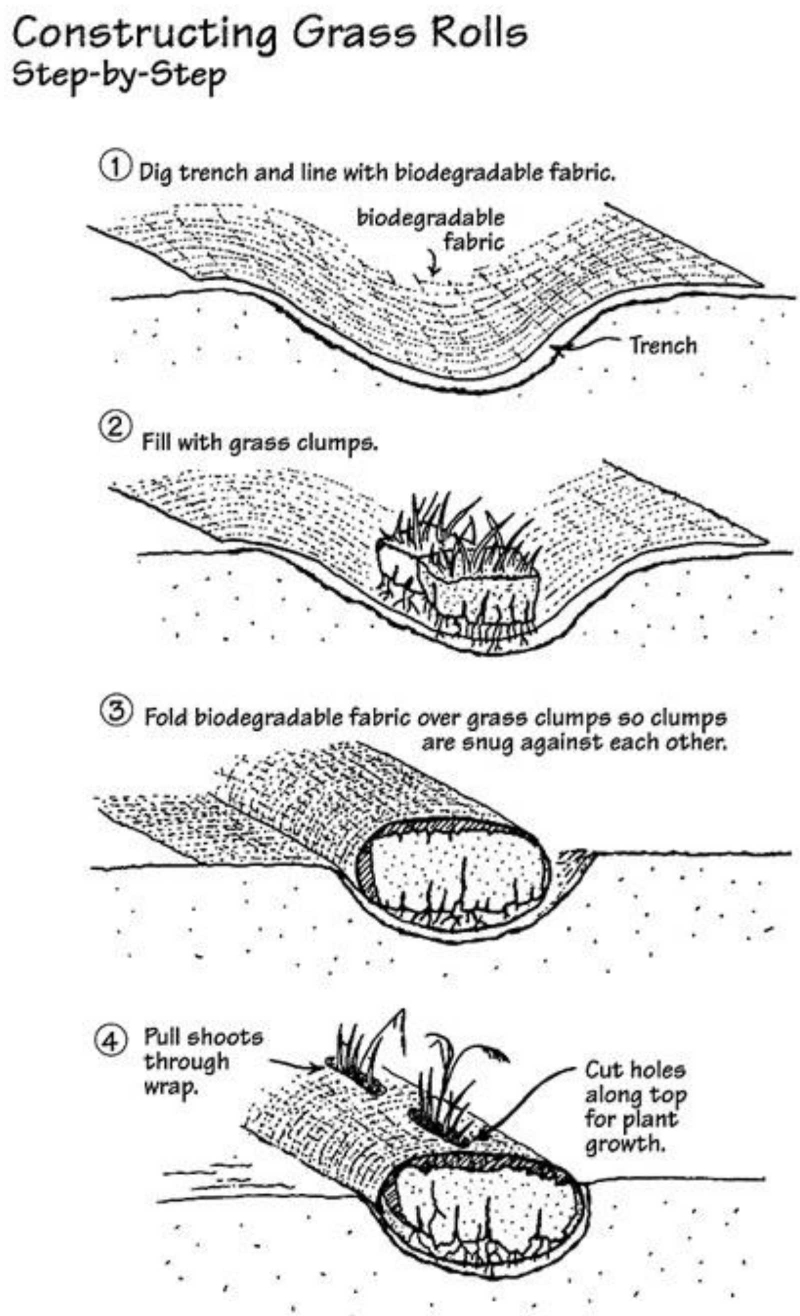


Figure 6- 27. Step-by-step guide to grass roll construction (ADFG, 2005).

Figure 6- 28. Grass roll installation at the mouth of Willow Creek, Alaska (ADFG, 2005).

Coir Logs

Coir logs are constructed of interwoven coconut fibers that are bound together with biodegradable netting. Commercially produced coir logs come in various lengths and diameters (Figure 6-29). The product needs to be selected specifically for the site. Fiber logs composed of other sturdy biodegradable materials may function equally as well.

Figure 6- 29. Sherman family moving coir log to site at Big Lake, Alaska (ADFG, 2005).

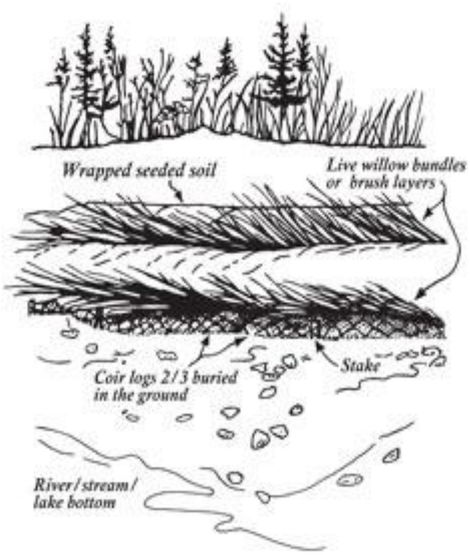


Figure 6- 30. Coir log location in proximity to water's edge (ADFG, 2005).

Applications for coir logs occur in many streambank, wetland and upland environments (Figures 6-30 and 6-31). The log provides temporary physical protection to a site while vegetation becomes established and biological protection takes over. The logs can provide a substrate for plant growth once the log decay process starts and protects native and newly installed plants growing adjacent to the log. This technique can be used as a transition from one revegetation technique to another and used to secure the toe of a slope in low velocity areas. Both the upstream and downstream ends of the coir log(s) need to transition smoothly into a stable streambank to reduce the potential for wash out.

Figure 6- 31. Installation of coir log toe protection, Eagle River, Alaska (ADFG, 2005).

- Install the logs to ensure contact with soil along the entire length. In most cases, excavate a shallow trench to bury the log 2/3 into the soil. At no time should the coir log span any open space that may occur between rocks, logs or uneven ground. Tie logs together that have been placed end-to-end and staked into place every foot (dependent on site conditions) on both sides. Wooden stakes or live stakes with biodegradable twine may be used to securely anchor these logs by interweaving supports and driving them into the bank. To provide fish habitat, use coir logs in conjunction with conifer tree revetment (see next section) and/or revegetation techniques. (Figures 6-32 and 6-33)

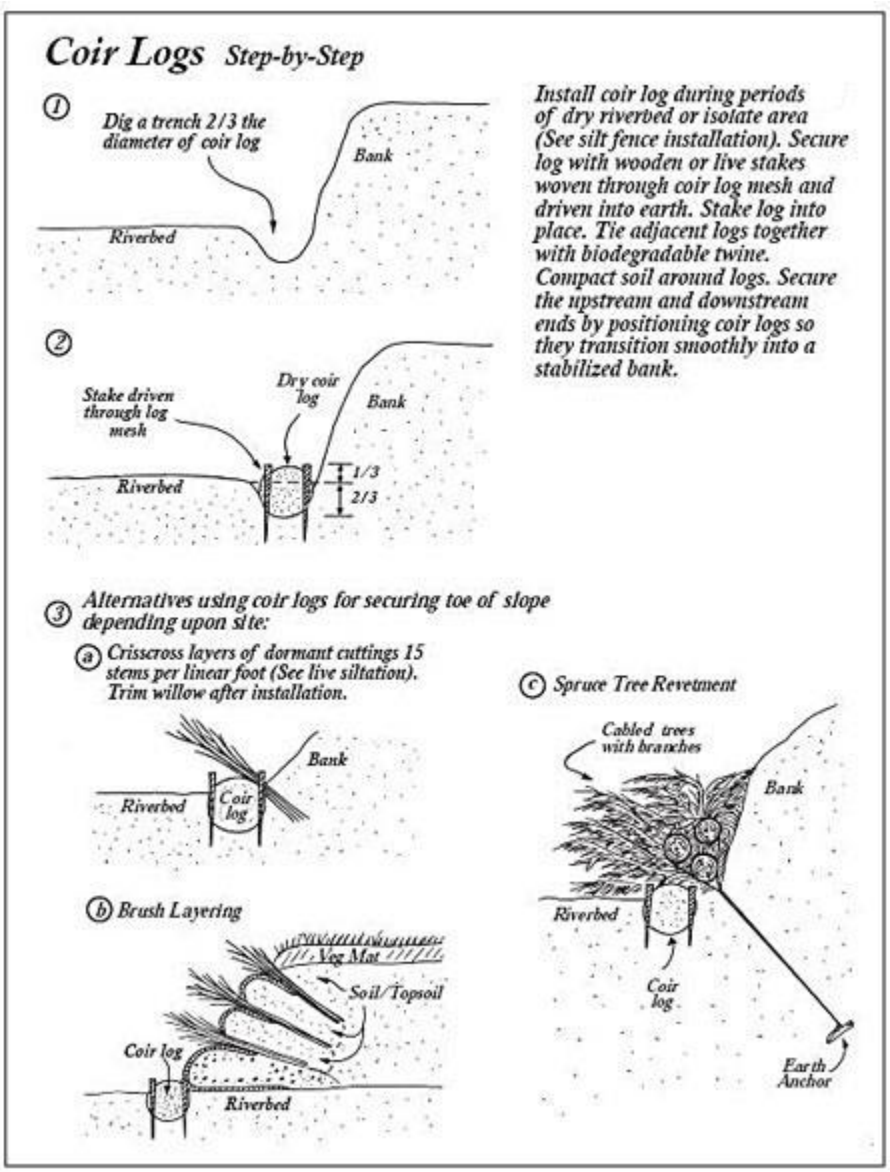


Figure 6- 32. Step-by-step guide to coir log construction (ADFG, 2005).

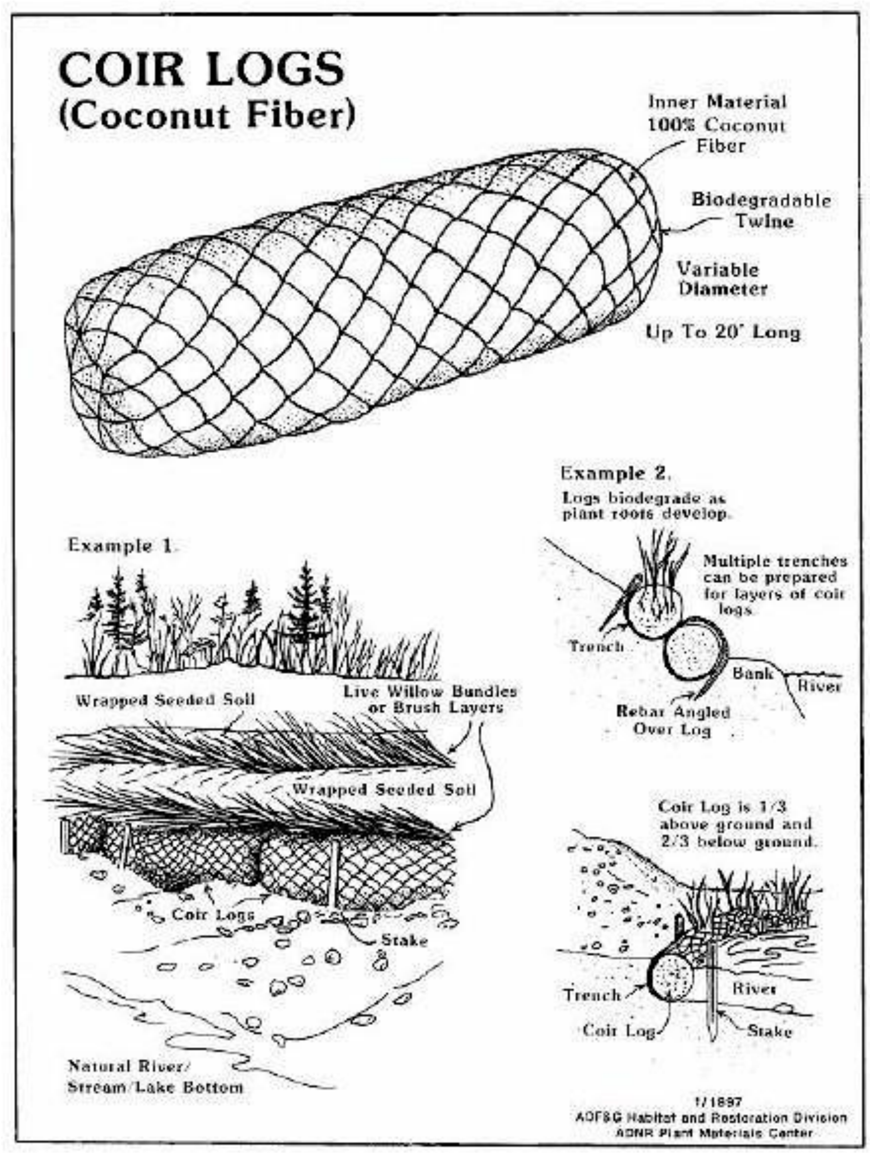


Figure 6- 33. Coir log installation (may be up to 20 feet long) (ADFG, 2005).

Advantages:

- Requires minimal training
- Biodegradable toe-of-slope protection
- Easy installation

Disadvantages:

- Moderately expensive
- Least effective toe protection of techniques listed in this manual if used by itself
- Not recommended for high velocity areas

Conifer Tree Revetments

Conifer tree revetments protect streambanks from erosion and provide increased bank protection (Figure 6-34). This is a relatively inexpensive and functional bank protection technique. Conifer tree revetments trap sediment, and over time, aid in rebuilding bank structure and establishing long-term bank stability. The tree limbs reduce near-bank water velocities, provide protection from scour and erosion, provide cover for juvenile fish, and act as a source of organic debris.

Figure 6- 34. Cabled spruce trees and brush layering immediately after installation of a conifer tree revetment, Ciechanski Recreation Site, Kenai River, Alaska (ADFG, 2005).

Conifer tree revetments are often used in combination with revegetation techniques. They provide immediate cover for fish until living plant cover is provided by the revegetation techniques. Consultation with a streambank revegetation specialist is necessary to determine site needs and revetment design. Conifer tree revetments may involve a single layer of conifer trees, multiple conifer trees cabled together, or single layers stacked (Figure 6-35). All revetments require an adequate cable and anchoring system. Selected trees should be green and limber with many branches. When collecting, be careful not to damage surrounding vegetation when harvesting and transporting trees. Anchor conifer tree revetment into well-vegetated and non-sloughing banks at both upstream and downstream ends.

- Install 4-6 inch diameter conifer trees parallel to the streambank and overlap 1/3 to 1/2 of their length in a shingle fashion (Figure 6-36). The top of the tree should be orientated downstream. Care should be taken to avoid unnecessary damage to, or removal of, tree limbs. The trees are secured tightly to the bank with 1/8-inch cable and earth anchors every 4-6 feet. In higher velocity systems, 3/16 cable and larger and more frequent earth anchors may be used.

- Maintain conifer tree revetments by adding new trees every 1-3 year(s). Fresh, bushy trees may be cabled directly in front of the original revetment. Conifer trees must be anchored securely and checked yearly to replace cable and add new trees. Remove excess cable and retighten any loose cable around trees. If the trees are not maintained and the trees deteriorate over time, any visible cables or anchors should be removed from below ordinary high water.

Figure 6- 35. Sediment in cabled spruce trees in a conifer tree revetment, Kenai River, Alaska (ADFG, 2005).

Advantages:

- Easily installed, no heavy equipment needed
- Materials readily available
- Inexpensive
- Provides soil erosion protection and fish habitat
- Least intrusive of bank protection techniques

Disadvantages:

- Maintenance required every 1-3 year(s)
- Must remove excess cable/visible anchors and add new trees as necessary

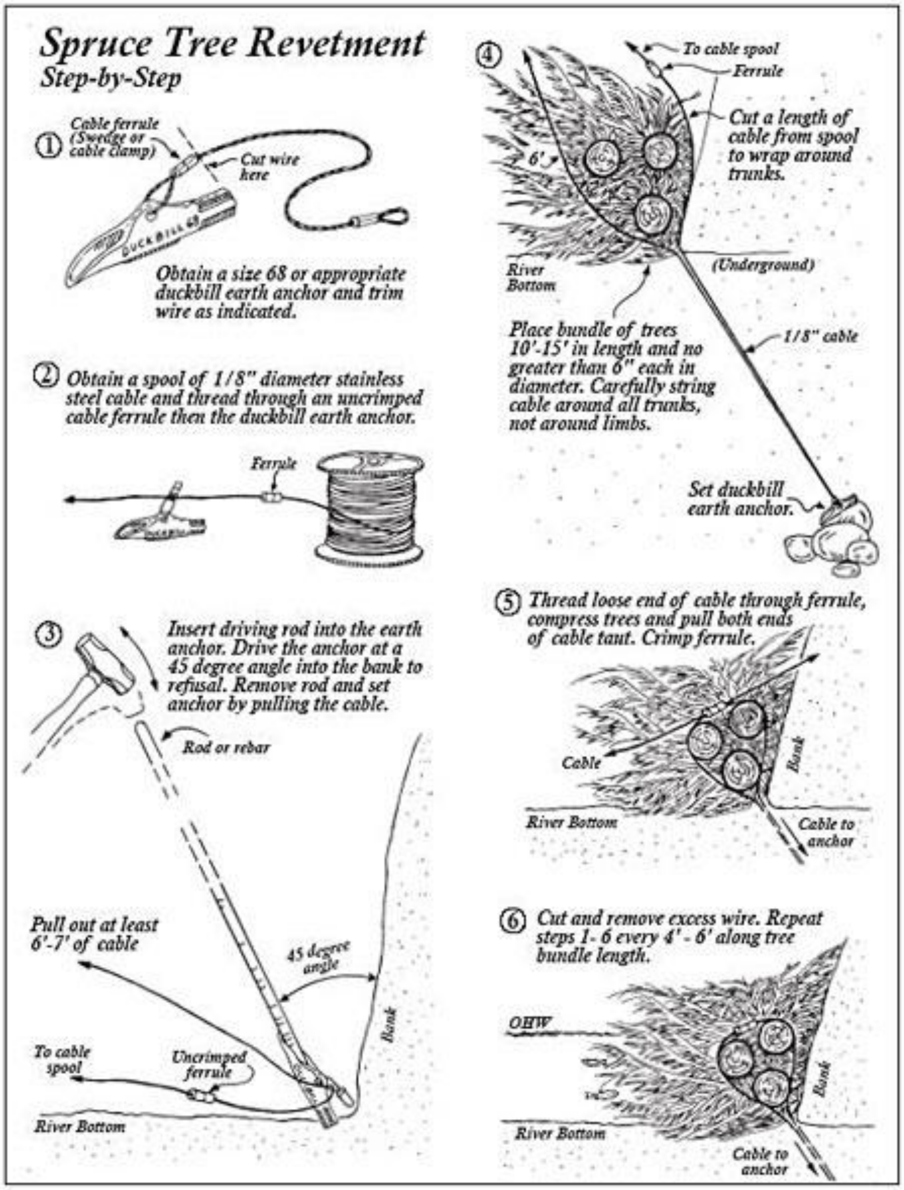


Figure 6- 36. Step-by-step guide to conifer tree revetment placement. The example shows a spruce tree revetment (ADFG, 2005).

Root Wads

Root wads are a streambank protection technique that provides immediate riverbank stabilization, protects the toe-of-slope and provides excellent fish habitat, especially for juveniles. They provide toe support for bank revegetation techniques and collect sediment and debris that will enhance bank structure over time and reduce erosion. Because of their size, root wads usually require the use of heavy equipment for collection, transport and installation (Figures 6-37 through 6-39). Consult a streambank revegetation specialist before any streambank revegetation or stabilization technique is utilized in this book.

Figure 6- 37. Harvested rootwads before installation (ADFG, 2005).

- Identify a collection site and obtain permission to remove trees. Collect root wads from forested areas being cleared for development, or selectively remove from treed area (Figure 6-37). Do not remove trees from riparian zones. Be careful to avoid damage to other trees and vegetation during collection and clearing of rood wads. Larger diameter trees (minimum of 12 inches DBH diameter breast height) can be pushed over when soils are not frozen, leaving root fans intact. The tree tops should be removed, leaving the trunks (boles) a minimum of 10 feet in length with root fans attached. Optimal root fans are a minimum of 5 to 6 feet in diameter.
- Construct during times of dry riverbed or isolate work site to prevent sediment erosion into adjacent water bodies. Determine ordinary high water level for proper placement of root wads and subsequent vegetative layers (Figure 6-40). It is imperative to tie in project to the existing stabilized streambank at the upstream and downstream ends of the project.
- Install root wad by excavating into the riverbank deep enough to accommodate an 8 to 10 foot long tree bole (Figure 6-41). Optional header and footer logs may be installed and pinned in place using rebar to help stabilize root wads and the bank. The bole of the root wad is placed into the prepared excavated bank and back-filled with 4-6" rock and gravel encased in two layers of biodegradable fabric. The inner layer of fabric is a fine biodegradable mesh (example: Bon Terra's® ENC2, North American Green's C125 BN, or equivalent) and is placed inside the larger mesh fabric (example: Bon Terra's® CF7, North American Green's CCM-700, or equivalent).

The bole is typically embedded at the level of the riverbed, perpendicular to the river, with the fans parallel to the bank. This placement requires that the riverbed be excavated to partially bury the root fan 2 to 3 feet. Root wads should be installed so that the root fans overlap adjacent root wads to provide continuous coverage along the bank area being treated (Figure 6-40). The fans should be positioned to undulate with the natural bank, providing additional cover for fish. Additional application methods are described in Applied River Morphology (Rosgen, 1996). Various revegetation techniques may be applied above ordinary high water level after root wad installation to establish native vegetation on the bank. The Step-by-Step Instructions (Figure 6-41) demonstrates brush layering and vegetative mat installations to revegetate the bank above the root wads. To learn more about these methods, please consult the appropriate sections of this document.

Advantages:

- Most stable toe-of-slope protection of techniques mentioned in guide
- Provides fish habitat
- May be used in higher velocity situations
- Helps keep foot traffic off project site

Disadvantages:

- Root wads help limit access to fishery unless grated walkway (gratewalk) and stairs are provided
- Expensive
- Labor intensive
- Heavy equipment required, generally requires contractor
-

Figure 6- 38. Rootwad installation at Pioneer Lodge, Willow Creek, Alaska (ADFG, 2005).

Figure 6- 39. Root wad, rock layer with header pinning (ADFG, 2005).

Figure 6- 40. Pioneer lodge root wads at low water levels (ADFG, 2005).

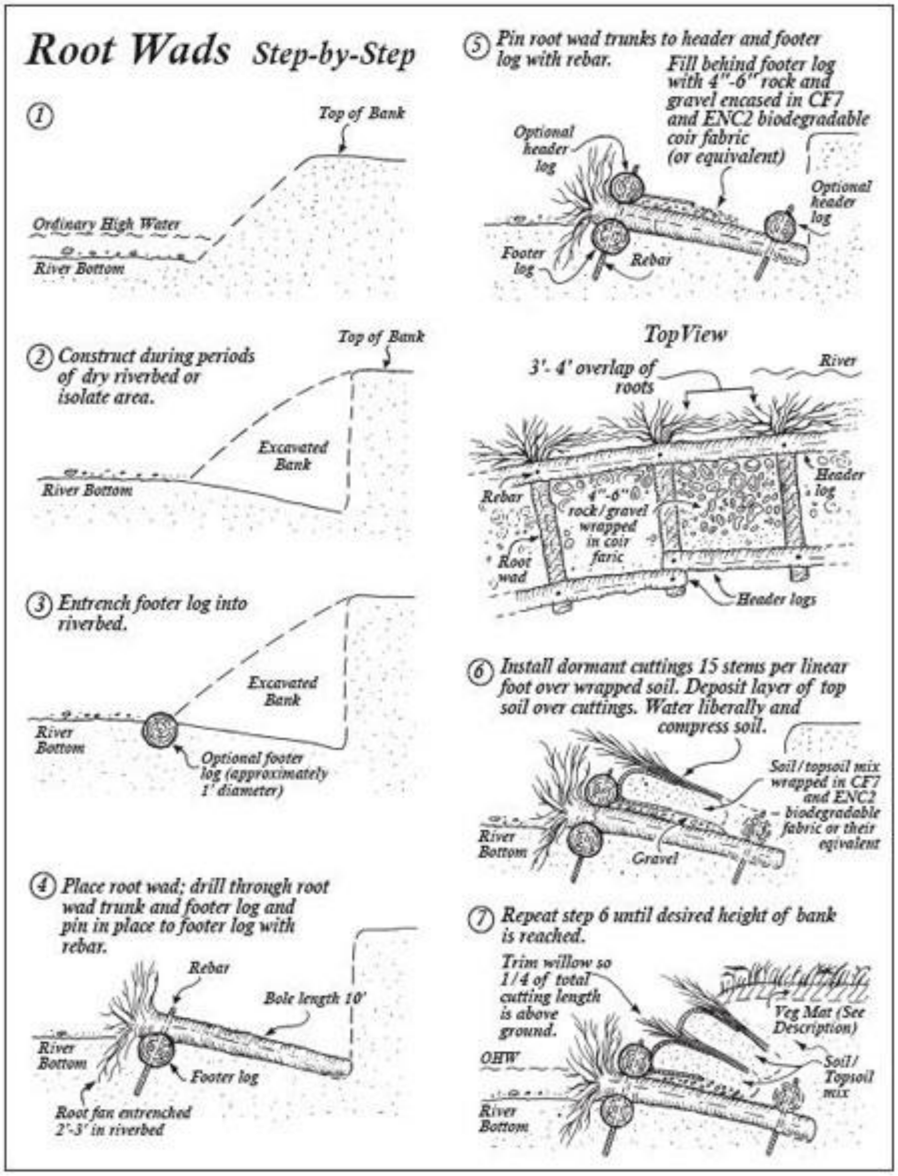


Figure 6- 41. Root wad step-by-step installation guide. (Consult an experienced professional to ensure rootwad placement is as effective as possible.) (ADFG, 2005).

Flow-Redirection Techniques and Structural Techniques

The Integrated Streambank Protection Guidelines (Washington State Aquatic Habitat Guidelines Program, 2002) is a great resource for flow-redirection and structural techniques. These types of techniques include the use of riprap. Permitting and consultation for bank stabilization through the Army Corps of Engineers, Department of State Lands, and National Marine Fisheries Service may require the use of bioengineering which would incorporate features such as wood or rootwads with the use of riprap. Early discussions with the above mentioned agencies would be beneficial to those planning streambank protection projects.

6.2.e. Riparian Planting

Riparian vegetation is critical for bank stabilization, providing shade, providing potential instream large wood, and habitat for macroinvertebrates for fish. Riparian planting is conducted at a range of intensity levels. The lowest intensity is direct seeding of prepared ground (similar to pasture seeding) and the highest intensity uses transplanting of large trees with irrigation and fertilization (similar to landscaping a home). Most plantings are somewhere in the middle and the intensity used is based on site factors, available resources like time and money, and the commitment level of the landowner.

Site and project factors include: type and depth of soil; depth to water table; competing vegetation like reed canary grass and Himalaya blackberry; presence of herbivores like beaver, elk or voles; availability of plant species in different sizes; availability of irrigation water; size of maintenance budget; size of project; the extent of landowner participation; and plant maintenance. Landowner participation can include the extent of the project, site preparation, project implementation, and plant and fence maintenance.

After consideration of these factors and consultation with the landowner, a restoration specialist writes a site specific plan that details who does what when, site preparation details, plants used (sizes, numbers, and locations), fencing type used, offstream livestock water plan, and a detailed maintenance plan. The maintenance plan includes what work is done (control of competing vegetation, watering, replacement of mortality, fence maintenance), who does which activities, a schedule of activities and a maintenance budget.

A second or third planting in a future year may be needed to get the desired plant community. These plantings are done after the initial planting has changed site factors (soil stability, soil nutrients, shade, wind protection) to allow for the establishment and survival of the new species added in the later planting.

Because of the uncertainty associated with future climate change, an increased likelihood of both summer drought and winter flood should be considered when planning riparian restoration projects.

Planting Design Criteria

- Identify a succession of plant species as a stepwise approach to re-establishing climax vegetation types. Identify reach based species-specific planting recommendations.
- Propose threshold conditions that would trigger the next planting phase.
- Assess the benefit of re-establishing vegetation on gravel bars; suggest restoration sites and techniques if the practice is determined to be beneficial.
- Identify where top of bank planting would be beneficial and suggest vegetative succession and species.
- Identify where planting would be appropriate inside the channel on benched areas of the bank and suggest vegetative succession and species.

Plant Care and Preparation

The success of your revegetation project lies largely in your ability to properly select, collect, and prepare the appropriate vegetation for site installation. There are many opportunities to revegetate different types of habitat, from wetland or riparian areas to upland areas, depending on the availability and identification of donor species and your site specifications. Always select a healthy plant community as a donor community and gain permission from the landowner before removing plant material. Consult an expert when identifying donor plants for use in revegetation projects so the correct species will be planted in appropriate growing environments.

Dormant Cuttings

Dormant cuttings are the primary plant material used in revegetation techniques including: live staking, brush layering, live siltation, brush mat and bundles (fascines). Dormant cuttings are harvested from living woody plants in a dormant (not actively growing) state. The cuttings are collected from plants that can root easily, without special treatment, such as certain willow species, cottonwood, and creek dogwood (see Appendix A for scientific names).

- Locate a harvest site and obtain permission to collect cuttings. Harvest sites are easier to identify when leaves are present. It is beneficial to locate harvest sites in the spring/summer or by utilizing a plant guidebook that covers Western Oregon. Do not over harvest site. The site should contain at least 3 times the needed harvest material or you should harvest from several sites.
- Collect cuttings during winter/early spring before leaves appear, preferably before the end of February, if they are to be used for spring plantings. For fall plantings, collect cuttings in the early fall of the same year, after plants have gone dormant (at least 50% of the leaves have changed color or have dropped). Cuttings may be tied in bundles with colored twine for ease in identification and carrying. Label each bundle with species, date collected, and number of cuttings.
- Select cuttings with leaf buds near the top of each cut line. Avoid flower buds (pussy willows) if possible; these buds typically occur at the tips of branches produced during the last growing season. These branch tips tend to be smaller than 1/4 inch in diameter.
- Select branches 1/2 to 2 inches in diameter and at least 3 to 4 feet long (Figure 6-42). If necessary, branches can be cut to a shorter length at the time of installation. The potential for drying during storage is reduced when the cuttings are stored in longer pieces.
- Store cuttings properly to maintain viability. If collection occurs while daytime temperatures remain below freezing, freeze at no colder than 0°F or refrigerate the cuttings until planting. If daytime temperatures are above freezing during collection, cuttings should be refrigerated between 31°F to 40°F and 60 to 70 percent humidity. Frozen cuttings can be stored with a small amount of snow to help reduce drying. No water or burlap should be added to the stored frozen cuttings. Monitor the condition of the cuttings regularly to detect problems such as drying, sprouting or mold.

- Only the plant material required for each day should be removed from storage, and placed in water, particularly if the weather is windy and/or warm at the revegetation site. Cuttings may be soaked in cool/cold water from 24-48 hours directly before planting to improve survivability. On site, the cuttings should be stored away from direct sunlight, heeled into moist soil, or stored in water until planting. Do not have cuttings in water for more than 4 days.
- Plant dormant cuttings as soon as the soil has thawed and no later than March or April depending on the site, or plant in the fall before the ground freezes. The ability of plantings to become established and resume growth in the spring declines quickly for plantings made after March or April (depending on the site). Do not use cuttings if they have begun to root, mold, appear dry or leaf out. If the project is delayed and rescheduled for fall, do not try to store the cuttings that were collected in the spring until fall. Plan on preparing new cuttings once the plants have gone dormant.

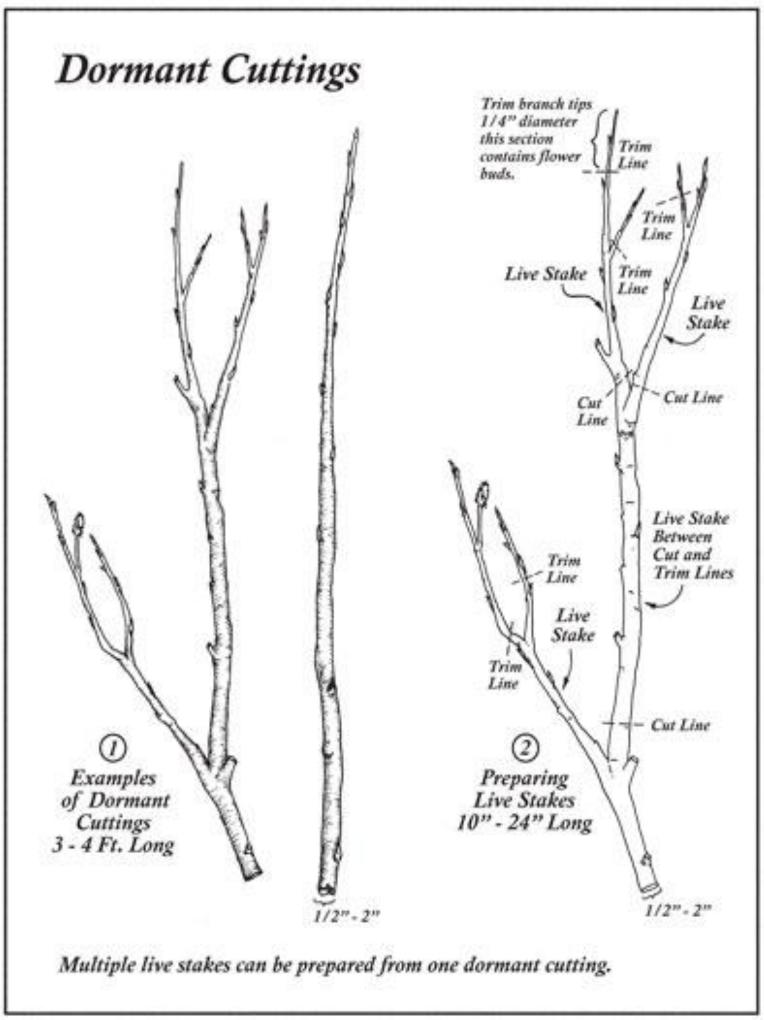


Figure 6- 42. Dormant cuttings - the essential building block of nearly every bank stabilization technique (ADFG, 2005).

The following are strategies for successful riparian planting.

- Watering plants at least 2 times a week (deep soak watering) significantly increases survival of installed plants, especially in dryer soils and/or in dry years.
- Watering plants immediately after installation and before installing the next layer helps to compress the soils in each installed layer and removes air pockets around plants, ensuring better plant to soil contact.
- Plant willow cuttings with 1/4 of the stem length above the ground and 3/4 the stem lengths below the ground for live staking and brush layering.
- Trim shoots of harvested transplants to compensate for root loss and to promote root growth. As an example, vegetative mat should be trimmed by 1/3 of the shoot length to compensate for root loss and to promote root growth.
- Store plants in snow banks or by refrigeration through their dormancy period to increase survival when planted.
- Cuttings should be soaked in water, out of direct sunlight, from one to four days prior to planting.
- Allowing plants to stay in direct sunlight or to dry out dramatically reduces plant survivability.
- All dormant cuttings should be used within four days of removal from refrigeration and as soon as possible in the winter that they are harvested.
- Fall plantings should occur as the plants are returning to the dormant state.
- Acclimate potted plants for spring plantings by hardening plants near the planting site. These plants should be kept moist during this hardening, then watered to capacity prior to planting. Do not allow greenhouse plants to be exposed to freezing temperatures while in pots during this hardening process.
- Plants are dormant in the fall when at least 50% of the leaves fall off or change color.
- Fertilizers are generally not necessary for native species revegetation of streambanks, especially for woody plants.
- If fertilizer is needed, use carefully as fertilizers may spread off-site into the adjacent stream and be harmful to fish and other aquatic organisms.

Riparian Vegetation Succession

Riparian vegetation colonizes stream/river banks following disturbances such as floods, erosion, fires, landslides or human disturbance. The colonizers (Zone 1 see Figure 6-43) include shrubby willows, creek dogwood, annual grasses and annual forbs. The colonizers stabilize the site and modify site factors that affect vegetation. The site factors that change include slowing of flood waters, soil accumulation and stabilization, accumulation of organic matter, development of shade and wind protection, development of cover from herbivores like beaver and deer, and gaining elevation above the summer low flow water level.

A second riparian community (Zone 2 see Figure 6-43) starts to become established when the site is stable, the soil has better water holding capacity and more nutrients, is elevated due to soil accumulation, and has some cover to help protect against wildlife/livestock herbivory. This community includes black cottonwood, Oregon ash, tree willows (Scouler's and Sitka), red alder, shrubs like ninebark, Indian plum, poison oak, ocean spray, vine maple, mock orange, wild grape, and native blackberries, grasses, and perennial forbs. Note that scientific names for these plants and others in this section can be found in Appendix A.

A climax community becomes established after the floodplain has developed (Zone 3 see Figure 6-43). The floodplain has well developed, fertile soil with good water holding capacity and is only flooded by a two to five year or greater event. The trees are long lived and slower growing and include Oregon myrtle, big leaf maple, Oregon ash, and some black cottonwood and red alder. Some floodplain areas near Powers will also support conifers such as Douglas fir, western redcedar, incense cedar, Port Orford cedar, western hemlock and grand fir. Some shrubs live in the shade under the trees such as snowberry and poison oak along with native blackberries, perennial grasses and perennial forbs.

On a bank layback project a vertical bank is sloped back to a 2:1 angle from the summer low flow level to the floodplain height. To plant this project the slope is divided into three zones that can support the three riparian communities. Zone 1 starts at the edge of the active channel (see Figure 6-43) and extends roughly a third to half way up the bank. Zone 1 is planted with the colonizer plants that withstand the erosive force of the water. Zone 2 starts above Zone 1 and extends to the top of the slope (mean high water or bankfull). Zone 2 is planted with the second riparian community that will further stabilize and develop the soil. Zone 3 is on the floodplain surface and is the buffer between floodwaters and human uses of the floodplain.

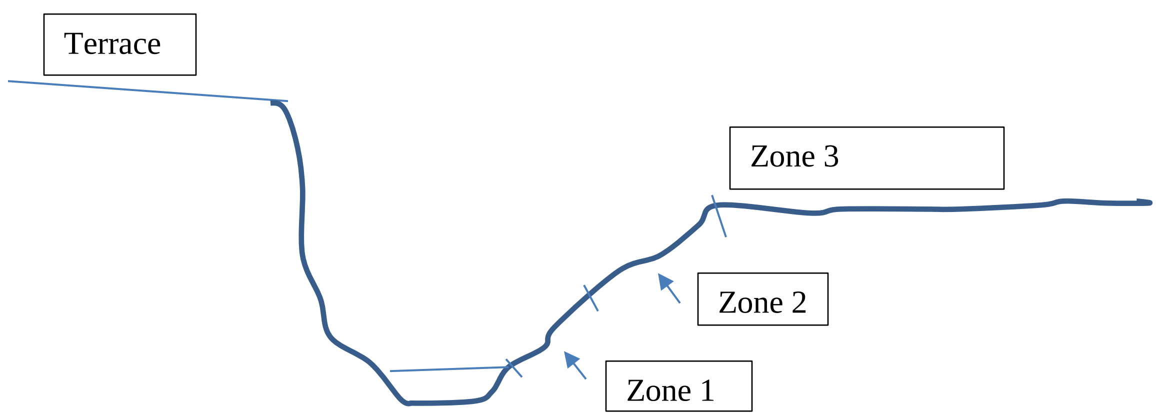


Figure 6- 43. Cross section depicting a bank layback project with corresponding riparian planting zones.

Deciding When to Plant or Not Plant Riparian Vegetation

Riparian plantings, which are fenced off from livestock, are a key component of bank stabilization. However, there is vertical entrenchment and lateral instability in lower reaches of the South Fork Coquille River (See Chapters 4 and 5) and some banks are not suitable for planting at this time. For example, on the outside of meander bends where the river is incised and widening, streamflow is undermining the banks at high flows with such force that riparian plantings root reinforcement cannot resist the progress of the erosion. Therefore, meander erosion potential needs evaluation by a revegetation specialist and/or hydrologist for each proposed site for riparian plantings. Only those sites that are determined to be relatively stable over time are candidates for planting. Bioengineering solutions along large rivers often require bank shaping and/or structural treatments (large wood, rock, and geotextiles) in tandem with the riparian plantings.

6.2.f. Riparian Fencing

Livestock Fencing

A useful resource for fencing designs and drawings is a set of NRCS Technical Notes. The first is a Pasture and Range Fence Technical Note (NRCS, 1990). The second is Fence Designs and contains standard drawings for a variety of fencing situations (NRCS, 1997). When reviewing the above mentioned two NRCS Technical Notes, careful attention should be made to make sure the design in not intended for arroyos or huge expanses of range land.

Fencing projects would be implemented by constructing fences to exclude riparian grazing, providing controlled access for walkways that livestock use to move across streams and through riparian areas. In addition, livestock use in riparian areas and stream channels will be reduced by providing upslope water facilities (See section below on Off-Channel Livestock Watering Facilites).

- Fence placement would allow for lateral movement of a stream and to allow establishment of riparian plant species. To the extent possible, fences would be placed outside the channel migration zone and other areas frequently impacted by high water.
- Minimize vegetation removal, especially potential large wood recruitment sources, when constructing fence lines.
- Where appropriate, construct fences at water gaps in a manner that allows passage of large wood and other debris.
- Consider flood regimes carefully when designing a fence line. Sections of drop-down, breakaway, or removable fences may be the most cost-effective option where cross-field flow and debris have destroyed fences during past high water events (confirm funding eligibility where appropriate). Removable design options may be found in the NRCS Technical notes described above and in commercial fencing product catalogs.

Off-Channel Livestock Watering Facilities

Consideration should be made during project development if fencing will be constructed to exclude livestock 100% out of rivers, creek and streams; there should be measures taken or funds requested to develop off-channel watering systems.

- Water withdrawals would not dewater habitats or cause low stream flow conditions that could affect ESA-listed fish. Withdrawals would not exceed 10% of the available flow.
- Troughs or tanks fed from a stream or river must have an existing valid water right. Surface water intakes must be screened to meet the most recent version of NMFS fish screen criteria, be self-cleaning, or regularly maintained by removing debris buildup. Regular inspection and as-needed maintenance should occur to ensure pumps and screens are properly functioning.
- Place troughs far enough from a stream or surround with a protective surface to prevent mud and sediment delivery to the stream. Avoid steep slopes and areas where compaction or damage could occur to sensitive soils, slopes, or vegetation due to congregating livestock.
- Ensure that each livestock water development has a float valve or similar device, a return flow system, a fenced overflow area, or similar means to minimize water withdrawal and potential runoff and erosion.
- Minimize removal of vegetation around springs and wet areas.
- Construct a fence around the spring development to prevent livestock damage when necessary.

6.2.g. Rapid Riparian Restoration

In some riparian revegetation cases the best approach is to implement an intensive planting plan after thorough removal of competing vegetation. This technique, called Rapid Riparian Restoration, consists of planting 2,200 – 2,600 smaller plants per acre the first year followed by an interplanting the second year of 530 – 650 plants per acre. The intensive planting is a substitute for site maintenance (such as watering and weeding), as there is limited or no maintenance planned at the site. Using this technique many revegetation sites can be established in six to seven years. This approach is applicable when the site under consideration has no livestock accessing it during the establishment phase and has adequate soil moisture. (Guillozet et al., 2014)

Designing a Rapid Restoration Revegetation Project

To begin the planning process the following factors are evaluated relative to the project area: flood events, periods of inundation or drought, sediment deposition or scour, lateral channel migration, herbivory, other disturbance factors, and the species composition of reference sites at intact native riparian stands. These factors are used to select species, determine appropriate densities for each species and to lay out those species across the site. Plants are contract grown from locally collected seed and cuttings to ensure they are adapted to local climate and soils.

Small bareroot seedlings are used because they have better root-to–shoot ratios and are thus better suited to riparian conditions.

Short statured native grasses seeded between the planted seedlings establish cover and deter competing vegetation. Different types of plants, including trees, arborescent shrubs, small shrubs, and thickets are planted at densities and layouts similar to the reference sites. The interplant after one year allows for adjustment to mortality and unanticipated site factors or damage to the plantings. (Guillozet et al., 2014)

An experienced revegetation specialist is required for the design of these projects.

Advantages: (Guillozet et al., 2014)

- Thorough consideration of site factors ensures that there are no surprises that can cause the project to fail
- Use of reference sites gives the range of species, densities, and layout appropriate for the site
- Can be cost effective
- Monitoring visits may still be used to catch problems in a timely manner and perform adaptive management
- Use of local sourced stock ensures plants are adapted to local climate and soils
- Reentry for interplanting after one year allows adjustment to the original plan and recovery from mortality

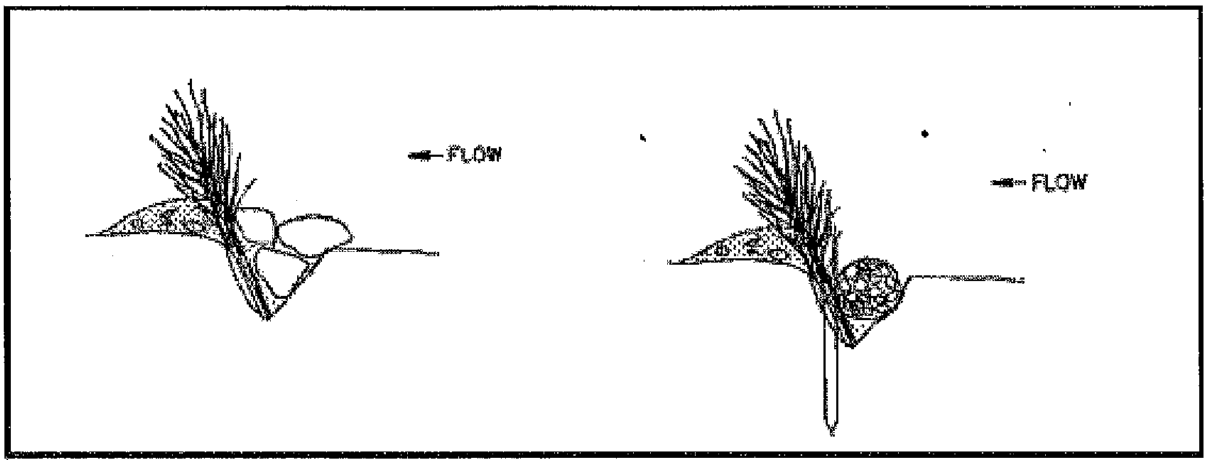
Disadvantages: (Guillozet et al., 2014)

- Requires lead time for seed and cuttings collection and nursery production of locally sourced stock
- Requires extensive knowledge of site factors and site history
- Smaller plants and no tubing or herbivory protection may result in major losses to herbivores
- Herbicides required for plant establishment and protection from rodent herbivory

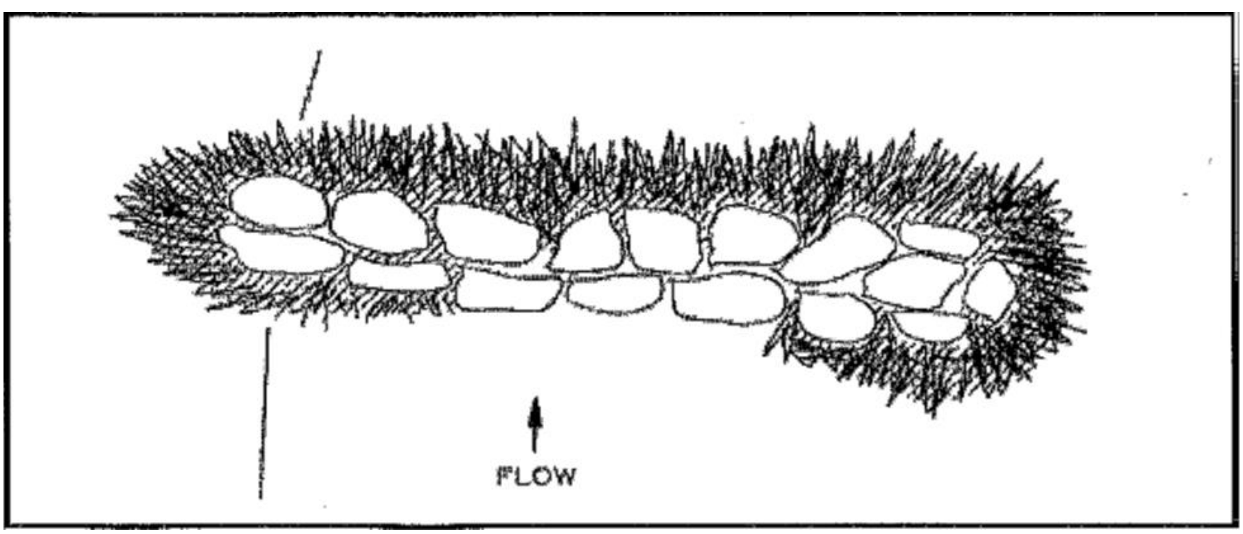
6.2.h. Live Siltation Baffles

Live siltation baffles is a bioengineering revegetation technique used to increase fine sediment capture on cobble bars. Fine sediment retention promotes riparian vegetation establishment and enhancement of fish habitat quality and quantity. The technique uses the flexible resistance of woody material to interact with fluvial processes creating flow zones of slowed velocity and reduced boundary shear stresses, and reduces entrainment of fine sediment particles. (Perala, 2014 and Beesley and Fiori, 2008)

This technique is applicable when unvegetated gravel bars need to be stabilized during the formation of new floodplain areas. The bars are first surveyed to analyze the meander dynamics and other potential erosion factors. In particular, it must be determined if meander migration or other erosion could seriously impact the proposed project area. The baffles are constructed perpendicular to the flow from large, unrooted, local cuttings (willow cottonwood, creek dogwood) placed in trenches, backfilled and anchored with riprap sized for the stream see Figure 6-44). These structures are designed to maximize sedimentation during floods and the potential stability of the structures depends, in part, on being integrated into a stable bank or bedrock feature. (Perala, 2014 and Beesley and Fiori, 2008)



Side View



Top View

Figure 6- 44. Diagram of Live Siltation Baffles (BioEngineering Associates, Inc., 2014).

An experienced revegetation specialist working with a hydrologist or geomorphologist is required for the design of these projects.

Advantages (Perala, 2014 and Beesley and Fiori, 2008):

- Promotes development of good fish habitat
- Promotes establishment and development of riparian vegetation on unstable bars
- Increases fine sediment deposition and retention on unstable bars
- Promotes development of unstable bars into stable floodplain

Disadvantages (Perala, 2014 and Beesley and Fiori, 2008):

- Bars are very dry and plantings may require supplemental irrigation
- Requires large quantities of native, unrooted, larger diameter cuttings
- Subject to damage by large flood events

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