Lower South Fork McKenzie River Floodplain Enhancement Project 80% Design Report

Photo: Disturbed reference reach within project area

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EXECUTIVE SUMMARY

Background

The South Fork is the largest tributary to the McKenzie River. In the lower 3.5 miles, the relatively confined glacial valley opens up into a wide alluvial valley where it meets the McKenzie River. Historically, this river confluence was a low gradient depositional zone for much of the sediment, wood, and nutrients coming out of the watershed. Floods frequently inundated the wide floodplain depositing nutrient rich organics and sediment, maintaining habitat needed to support ESA-Threatened spring Chinook salmon and bull trout, Pacific lamprey, rainbow trout, cutthroat trout, western pond turtle, harlequin duck, American beaver, and many other native species.

The South Fork McKenzie River has been significantly altered in the last century. Since the 1940s, logging has occurred throughout the watershed and removal of in-stream wood was a common practice. Cougar Dam was completed in 1963 at river mile 4.2 by the US Army Corps of Engineers (USACE). Associated with construction of the dam was the straightening and channelization of the lower river with levees and riprap and filling of the floodplain with substantial amounts of fill material to raise elevation and dewater the floodplain.

These impacts have led to impaired ecological conditions – only 17% pool area, wood density of less than 20 pieces per mile, substrate too large for spawning, and channel incision up to 13 feet in places, resulting in disconnection from side channels and floodplain. Once a biological hotspot, the lower South Fork now lacks suitable habitat for spring Chinook salmon and bull trout, Pacific lamprey, western pond turtle, and other native species.

Goals and Objectives

The Project area encompasses the lower 4.2 miles of the South Fork McKenzie River and includes two large alluvial valleys with broad historic floodplains. The Project is designed to rehabilitate to the maximum extent practicable the physical, chemical, and biological processes that support a healthy, resilient ecosystem.

We expect to achieve the following objectives:

1. Within the Lower Alluvial Valley, increase area of floodplain inundation and secondary channel habitat during annual peak flow (approx. 4,000 cfs) and during base flow (approx. 300 cfs) by at least 40% within 5 years of Project completion.
2. Within the Upper Alluvial Valley, increase area of floodplain inundation and secondary channel habitat during annual peak flow (approx. 4,000 cfs) and during base flow (approx. 300 cfs) by at least 100% upon Project completion.
3. Within primary channels in alluvial valley reaches, increase key LWM density to at least 200 pieces per mile (at least 24 inches diameter and 50 feet long with rootwad) and small LWM density to at least 400 pieces per mile (at least 12 inches diameter and 25 feet long) upon Project completion.
4. Within secondary channels and floodplain in alluvial valley reaches, increase small LWM density to at least 900 pieces per mile (at least 12 inches diameter and 25 feet long) upon Project completion.
5. Within alluvial valley reaches, increase pool area (% thalweg length) in primary channels from 19-25% to at least 40% within 5 years of Project completion.
6. Within alluvial valley reaches, decrease the mean particle size from cobble dominant (D50 = 128mm) to gravel dominant (D50 = 32-64mm) in primary and large secondary channels within 5 years of Project completion.
7. Increase spring Chinook salmon redd abundance by 25% within 5 years of Project completion.
8. For western pond turtles, create a minimum of 5 ponds or backwater areas at least 0.25 acres in size and at least 6 feet deep that are exposed to full sun for most of the day and place several pieces of LWM in and around each pond. Create 1-2 silt/clay substrate mounds per pond (10' x 10' x 2' deep) above the 10-year floodplain in south-facing sunny areas next to ponds. Seed with native, weed-free grasses.
9. For waterfowl, create 1-2 ponds or backwater areas at least 1.5 acres in size with at least 1 small island and several pieces of floating large wood upon Project completion.
10. Create numerous shallow, ephemeral pools on floodplain for amphibian breeding upon Project completion.

Design

The design principles incorporated into this 80% design focus on improving natural processes and functions. We employ a "process-based" approach to restoration, rather than a "form-based" approach, which has been shown to be more successful, effective, and sustainable.

The main design principles in this restoration plan vary by geomorphic reach. In the Lower Alluvial Valley – where the impacts are not as great, channel incision is moderate, there is intact riparian forest and future LWM supply, and there are areas currently functioning well – restoration actions will include the addition of LWM throughout the channels and floodplain, augmentation of gravels and fines, removal of riprap and fill, and construction of new ponds. The added LWM will dissipate stream energy causing deposition of the augmented sediment and sediment generated from within the channel network, floodplain, and banks. The channel will begin to aggrade and reconnect adjacent flow paths and floodplain. Sediment will be augmented periodically to maintain the sediment supply needed to keep the floodplain connected and to continue to develop high quality fish and wildlife habitat.

In the Upper Alluvial Valley, however, conditions are much more degraded. There is significantly more levee, riprap, and fill material and the mainstem channel is incised up to 13 feet in places. Because incision is extreme, restoring floodplain reconnection will require manual aggradation of the incised mainstem and secondary channels. Once the bed elevation is "reset", natural channel development can occur. Actions in this reach will also include removal of levee, riprap, and fill material, addition of LWM and sediment, and construction of a new channel network and new ponds.

Expected Outcomes

Proposed actions in the Lower Alluvial Valley as part of our design will encourage multiple flow paths as opposed to a primary channel with a bankfull width over 150 feet. Pool area is expected to increase from 19% to at least 40% and floodplain inundation is expected to increase by over 50% during peak and base flows. Large woody material will be added to meet reference conditions – at least 200 pieces per mile of "key" LWM (at least 24 inches in diameter and 50 feet long with rootwad) and at least 400 pieces per mile of smaller LWM (at least 12 inches in diameter and 25 feet long) in the primary channel. In secondary channels and across the floodplain an additional 900 pieces per mile will be added.

Proposed actions in the Upper Alluvial Valley are expected to lead to a 10% increase in primary channel length, decreasing channel gradient by 0.2% and increasing sinuosity from 1.1 to 1.3. Bankfull widths and width-to-depth ratios will decrease by up to 77%, pool area is expected to increase from 25% to at least 40%, and floodplain inundation is expected to increase by over 100% during peak and base flows. Large woody material will be placed to meet reference conditions discussed above with an additional 1800 pieces per mile added to secondary channels and floodplain due to a higher relative area of ground disturbance.

1.0 WATERSHED CONTEXT AND RESTORATION NEED

1.1 Watershed Context

The South Fork is the largest tributary to the McKenzie River, draining approximately 138,000 acres (Figure 1). It originates along the crest of the Cascades Range and terminates in a broad alluvial valley. The geology of the South Fork can be coarsely separated into two fundamentally different geologic settings that are largely differentiated as a function of age (FIGURE 2). Both settings consist of volcanic geology, with the younger "High Cascades" consisting of Quaternary deposits ranging from a few million years old to as young as a few thousand years old. The High Cascades geology is located in the southeast portion of the watershed where it ramps up to the crest of the Cascades south of the Three Sisters. The older "West Cascades" consist of Tertiary and older deposits that range from a few million years old to nearly 30 million years old. West Cascades geology occupies the northern and western portions of the watershed as is drains downward toward the main stem McKenzie River. Large springs emerging from the High Cascades provide cold, clean water while the older hillslope processes found in the West Cascades provide a rich source of sediment and large wood.

FIGURE 1. LOCATION OF SOUTH FORK MCKENZIE RIVER WATERSHED WITHIN THE MCKENZIE RIVER SUB-BASIN

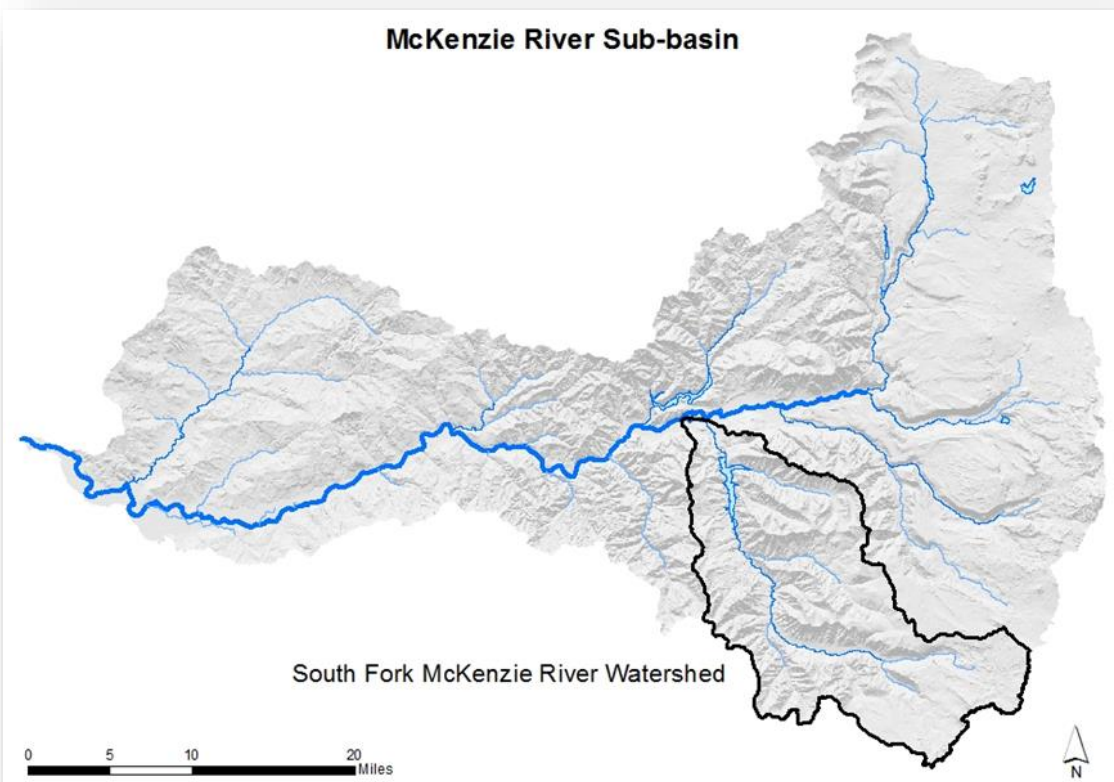
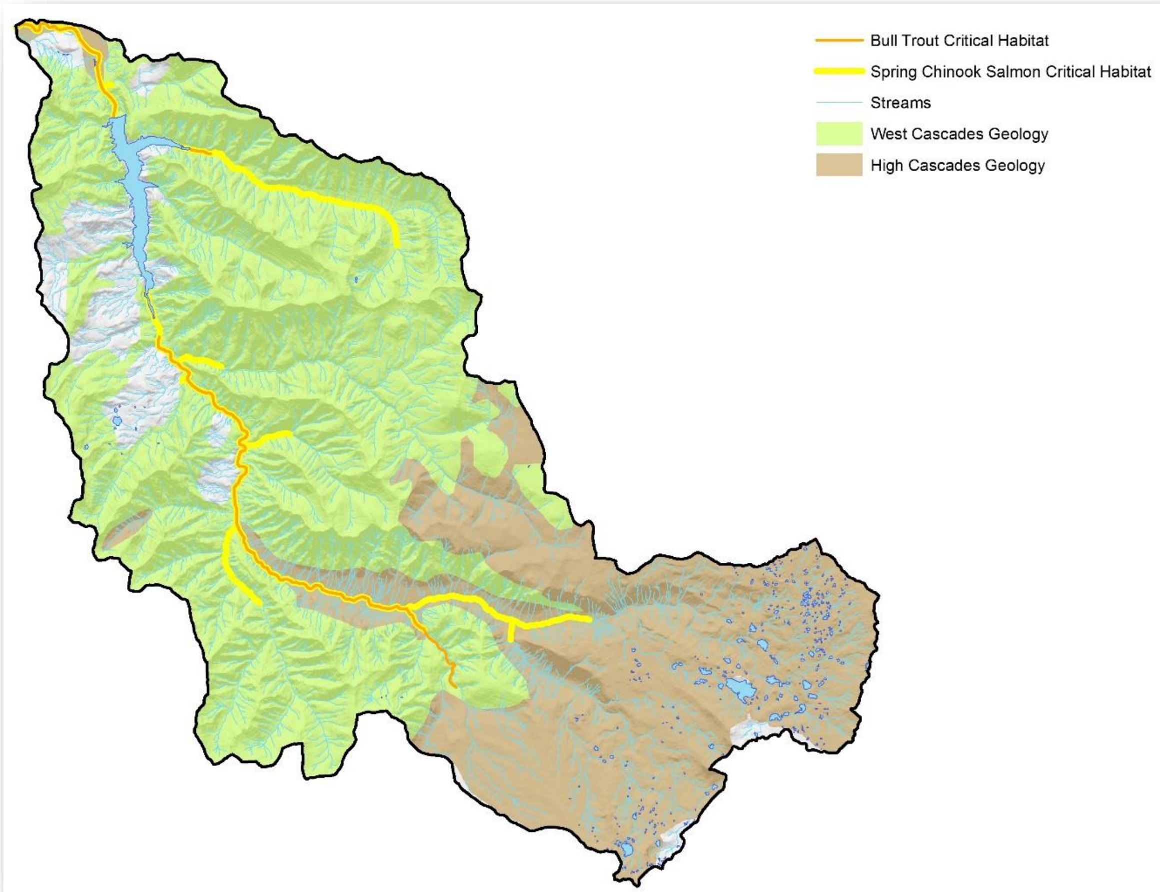
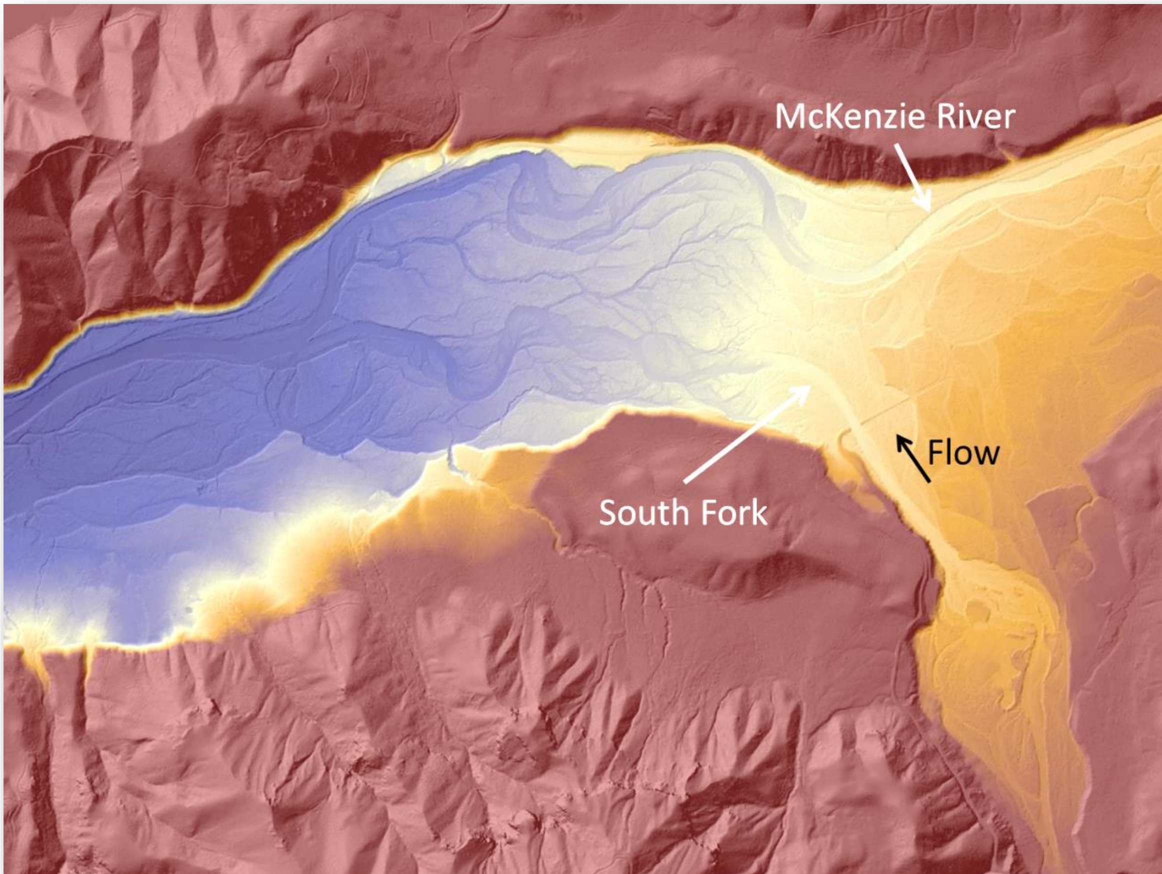


FIGURE 2. DOMINANT GEOLOGIC SETTINGS AND CRITICAL HABITAT FOR ESA-THREATENED BULL TROUT AND SPRING CHINOOK SALMON IN THE SOUTH FORK MCKENZIE RIVER WATERSHED.



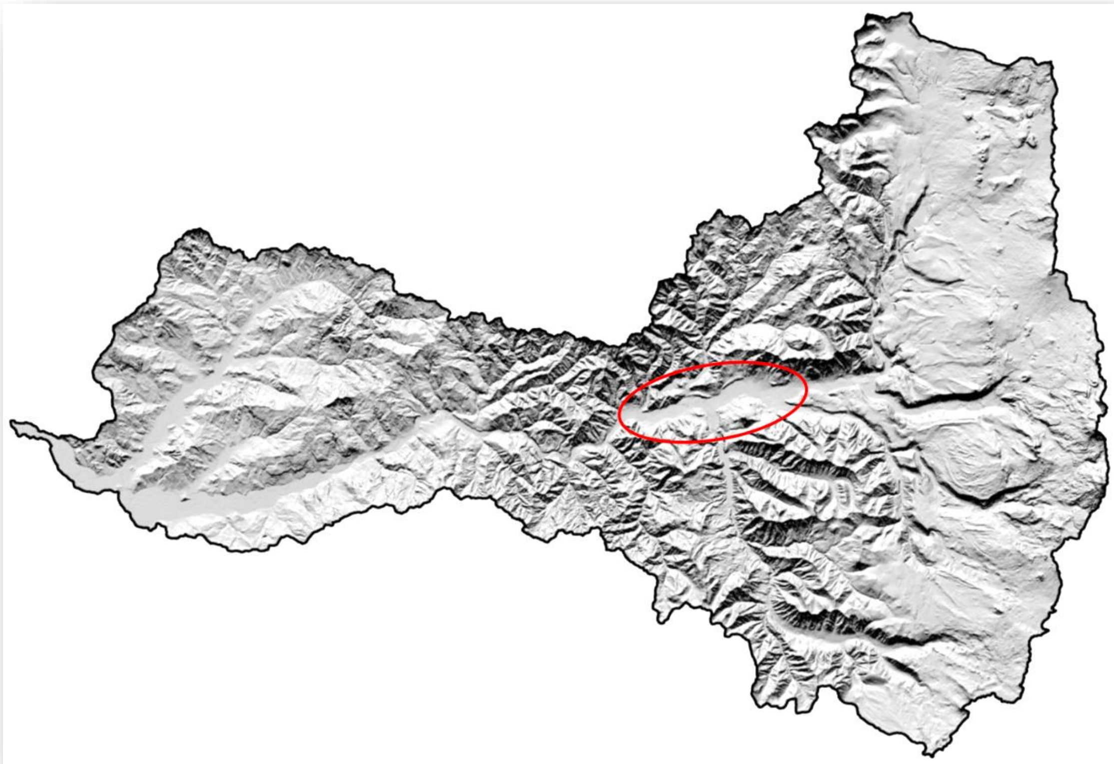
In the lower 3.5 miles, the relatively confined glacial valley opens up into a wide alluvial valley where it meets the McKenzie River (FIGURE 3**Error! Reference source not found.**). Historically, this river confluence was a low gradient depositional zone for much of the sediment, wood, and nutrients coming out of the watershed. Floods frequently inundated the wide floodplain depositing nutrient rich organics and sediment and maintaining a complex channel network with abundant gravels, wood, and deep pools – habitat needed to support ESA-Threatened spring Chinook salmon and bull trout, Pacific lamprey, rainbow trout, cutthroat trout, western pond turtle, harlequin duck, American beaver, and many other native species. In Western Oregon, riparian areas are known to regulate channel morphology, stream water temperatures, and nutrient flow (Hetrick et al 1998). The South Fork was no exception. The riparian vegetation historically exhibited a wide diversity of age and compositional structure. Mature Douglas-fir, western hemlock, and western red cedar were intermixed with younger hardwoods such as red alder, cottonwood, and willows.

FIGURE 3. ALLUVIAL VALLEY OF THE LOWER SOUTH FORK MCKENZIE RIVER SHOWN IN A LIDAR BARE EARTH IMAGE.



This alluvial valley, unique to the relatively constrained valleys of the upper and middle McKenzie River (FIGURE 4), was once very biologically productive. According to 1937 surveys by the Bureau of Fisheries, the South Fork was the most important tributary in the McKenzie River sub-basin for spring Chinook salmon spawning and could support a run of 13,000 adults (McIntosh et. al. 1994). Spring Chinook salmon redd abundance is unknown prior to 2001, but based on estimates of 13,000 adults once occupying the South Fork, redd abundance in the alluvial valley was likely in the thousands. Although bull trout spawning is limited to spring-fed Roaring River, a tributary to the South Fork at approximately river mile 18, they use the lower South Fork for foraging, overwintering, and migratory habitat. Historically, the lower South Fork was considered by locals a “bull trout paradise that was intensively fished” (McIntosh et. al. 1994). Historic and current Pacific lamprey use in the South Fork is largely unknown, but ammocoete presence was confirmed by the U.S. Forest Service (USFS) in the lower river in August 2015.

FIGURE 4. WIDE, UNCONSTRAINED VALLEY (CIRLED IN RED) UNIQUE TO THE UPPER AND MIDDLE MCKENZIE RIVER.



1.2 Impacts from Land Use and Development

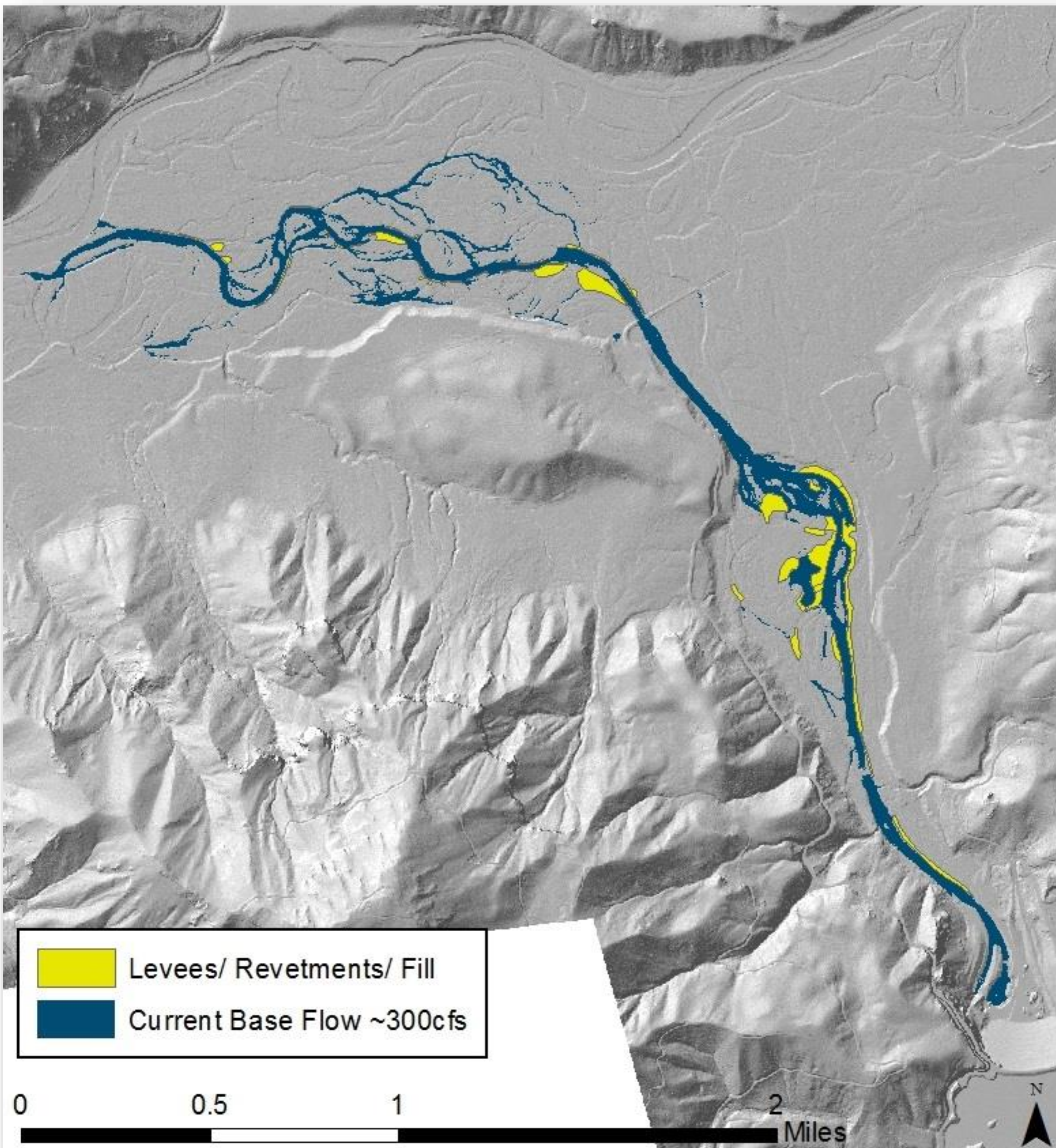
The South Fork McKenzie River has been significantly altered in the last century. Since the 1940s, logging occurred throughout the watershed, including riparian areas, and "stream cleaning" (i.e. removing in-stream wood) for timber and navigation purposes was a common practice. Cougar Dam was completed in 1963 at river mile 4.2 by the US Army Corps of Engineers (USACE) for flood control and power generation. Associated with construction of the dam was the straightening and channelization of the lower river with levees and riprap and filling of the floodplain with substantial amounts of fill material to raise elevation and dewater the floodplain (FIGURE 5).

These combined activities have altered the following physical and biological processes:

- Flow regime and stream flow routing
- Supply, transport, and retention of sediment, large wood, and nutrients
- Floodplain building and flood storage
- Pool and bar formation
- Channel migration
- Litter fall (reduced due to riparian conversion to conifers)

- Pond formation (reduced due to lack of beaver-preferred vegetation after riparian conversion to conifers)
- Secondary production (altered due to loss of nutrient delivery, loss of leaf litter, and lack of sediment supply/substrate diversity)
- Feeding/predation (altered due to changes in secondary production and physical habitat - e.g. loss of side channels)

FIGURE 5. LOCATION OF LEVEE, RIPRAP, AND FILL MATERIAL ALONG THE LOWER SOUTH FORK.



These impacts have led to impaired ecological conditions. A comprehensive Stream Inventory survey conducted by the USFS in 2005 revealed only 17% average pool area – about a 75% loss of pools since 1937 (Minear 1994) – and wood density of less than 20 pieces per mile. The dominant substrate in both pools and riffles is cobble – too large for spawning. The mainstem channel is relatively straight (sinuosity of 1.0 to 1.3; low values for a low gradient alluvial valley) and it is incised up to 13 feet in places, resulting in disconnection from side channels and floodplain. Fine sediment is no longer deposited onto floodplains, limiting nesting habitat for turtles and impacting riparian function. Once a complex river delta and biological hotspot, the lower South Fork now lacks suitable habitat for spring Chinook salmon and bull trout, Pacific lamprey, western pond turtle, and other native species. Major limiting factors for these species include:

1) lack of spawning gravel and fine sediment,
2) lack of off-channel habitat and high flow refuge,
3) lack of deep pools,
4) lack of cover,
5) lack of floodplain inundation and fine sediment deposition,
6) lack of shallow wetland habitat,
7) lack of basking structures such as logs, and
8) lack of open grassy nesting areas near waterbodies

Cougar Dam has also altered the biological productivity and integrity of local fish populations by obstructing migration. Original construction of the dam included both adult and juvenile fish passage facilities. However, due to downstream changes in river temperature, adult fish no longer migrated to its base so the USACE abandoned the original fish passage facilities. To fix downstream temperature issues, a temperature control facility was built in 2005. It draws water from varying depths within the reservoir, mixing it to a temperature that more closely replicates pre-reservoir downstream temperatures. With adult spring Chinook salmon and bull trout now migrating to the base of the dam in search of spawning grounds, an adult fish collection facility was built in 2010, which collects and transports migrating adults above the reservoir to access many miles of habitat. The new tower, however, poses serious challenges for juvenile spring Chinook salmon trying to migrate out to sea. All water passing Cougar Dam must flow though the tower, but flow conditions at the corner of the reservoir where the tower is located make it hard for fish to find and enter it. Passage efficiency and survival rates of those that do manage to enter the tower are not high enough to support a self-sustaining population above the dam. In 2014, the USACE installed a small-scale portable floating fish collector to help inform the decision-making and design of a future permanent downstream passage solution. The fish collector attracts and holds juvenile spring Chinook salmon until they can be transported around the dam. Plans to install a permanent fish collector are currently underway.

Until both upstream and downstream passage are successful, spring Chinook salmon production above Cougar Dam is very limited and they are primarily of hatchery origin.

The Oregon Department of Fish and Wildlife (ODFW) releases hatchery origin adult Chinook salmon above Cougar Reservoir each year (122-4,878 adults since 1996) to maintain a spawning population above Cougar Dam, to provide marine derived nutrients to the system, and to provide bull trout with a more robust prey base (ODFW, pers. com. 2015a). Only 187-496 natural origin adult Chinook have been collected at Cougar Dam annually since 2010 and released above Cougar Reservoir (ODFW per. com. 2015b). Chinook below Cougar Dam, however, are mostly of natural origin, but currently there is very little suitable habitat. Once in the thousands, Chinook redd abundance in the lower South Fork now ranges from 36-158 since 2001 (ODFW, pers. com. 2015b).

Before the adult fish collection facility was built, the lack of upstream passage for migrating bull trout had essentially fragmented a once connected population into two. Trail Bridge Dam in the upper McKenzie River, also without passage, further fragmented the population into three, dramatically decreasing the population size, genetic diversity, and gene flow between populations, reducing their chance of recovery and persistence. Bull trout are currently using the fish passage facility at Cougar but remain impacted by a massive reduction in their primary prey base, spring Chinook salmon fry and juveniles.

1.3 Restoration Need

Cougar Dam has taken its toll on river function, habitat, and fish and wildlife productivity in the South Fork McKenzie River. The need for restoration in the lower South Fork has been identified in several watershed planning and recovery documents, including:

- *South Fork McKenzie River Watershed Analysis* (USDA Forest Service 1998) and Update (USDA Forest Service 2009), which recognizes the importance of the South Fork as an aquatic refugia and recommends enhancement work below Cougar Dam, including reconnection of off-channel habitats, large wood and gravel augmentation, and flow regime changes.
- *Upper Willamette River Conservation & Recovery Plan for Chinook Salmon & Steelhead* (ODFW and NMFS 2011), which emphasizes actions that improve the amount, complexity, diversity, and connectivity of riparian, confluence, and off-channel habitat.
- *Coastal Recovery Unit Implementation Plan for Bull Trout Recovery Plan* (USFWS 2015), which promotes "stream, riparian, and upland restoration projects that improve habitat for bull trout and spring Chinook salmon as an essential prey base… Restoration activities should focus on: increasing instream habitat complexity, off-channel habitat, and high flow refugia by adding large wood." It further advises to look for environmental flow and wood, sediment, and nutrient supply improvement opportunities below dams.

- *Pacific Lamprey Assessment and Template for Conservation Measures* (Luzier et al. 2011), which outlines the need to reduce the threat of stream and floodplain degradation to Pacific lamprey.
- *USDA Forest Service Terrestrial Restoration and Conservation Strategy (TRACS)*, which has prioritized species most in need of restoration, conservation, or enhancement actions. The harlequin duck is a "very high priority species" on the Region 6 List of Priority TRACS Vertebrate Species for the West Cascades EcoRegion and the American beaver is a TRACS social and economic species. Both species are found in the Project area and will benefit greatly from restoration actions.

Because the South Fork is such an important tributary, partners in the McKenzie River Sub-basin continue to make it a top priority for restoration:

- The South Fork McKenzie River Watershed, managed almost entirely by the McKenzie River Ranger District (MRRD) of the Willamette National Forest (WNF), has been a priority area for restoration for many years. It has been designated a Tier 1 Key Watershed under the Northwest Forest Plan, which means it is of the highest priority for restoration. Due to spring Chinook salmon and bull trout distribution throughout much of the watershed (FIGURE 2), habitat improvement projects (primarily large woody material augmentation) have already been implemented on over nine miles of the upper river. In 2011, the Cougar Creek sub-watershed below Cougar Dam was selected as the priority sub-watershed (FIGURE 6) for the MRRD, under the Watershed Condition Framework (WCF; USDA 2011). The WCF was established to have a consistent, comparable, and credible process for improving the health of watersheds on National Forests and Grasslands across the country. In 2012, the *Cougar Creek Watershed Restoration Action Plan* was signed and essential projects were identified to move the watershed condition rating from *Functioning at Risk* towards *Properly Functioning*. The Lower South Fork McKenzie River Floodplain Enhancement Project (Project) is the last remaining essential project.
- In 2015 and 2016, the McKenzie Watershed Council (MWC) led an effort with various partners in the McKenzie River Sub-basin to identify and prioritize aquatic and riparian restoration actions needed to restore key ecological processes for key aquatic species at a sub-basin scale. The *McKenzie River Sub-basin Strategic Action Plan for Aquatic and Riparian Conservation and Restoration, 2016-2026* (Draft 2016) identifies this Project as one of the highest priority projects for the sub-basin.
- The Upper Willamette River Bull Trout Working Group, made up of various partners in the McKenzie and Middle Fork Willamette River Sub-basins fully supports and has been involved in development of this Project. It is listed as an important bull

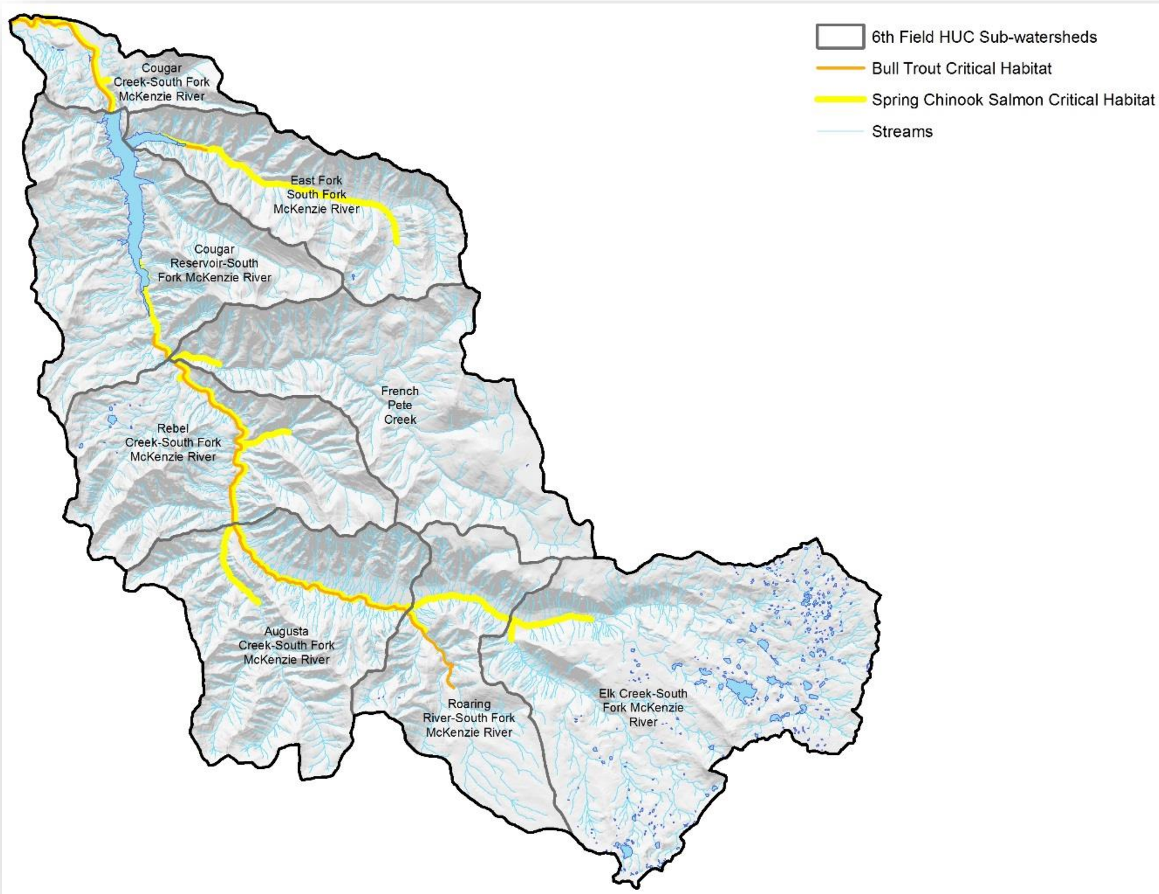
trout habitat improvement project in the *2016 Upper Willamette Basin Bull Trout Action Plan.*

- In 2015, the Lamprey Conservation Team selected the most important projects for Pacific lamprey. This Project is in the top five priority projects for the Willamette River Basin.
- In July 2008, the National Marine Fisheries Service (NMFS) and US Fish and Wildlife Service (USFWS) each issued a biological opinion (NMFS 2008; USFWS 2008) to the USACE, Bonneville Power Administration, and the Bureau of Reclamation to ensure that the continued operation of the Willamette Valley dams (including Cougar Dam) will not reduce the likelihood of survival and recovery of ESA-listed fish. In their biological opinions, the Services included mandatory measures to mitigate for the projects' effects, which include:
    - Continue capturing spring Chinook salmon below USACE dams and transporting them into habitat above the dams
    - Construction and operation of downstream passage facilities at Cougar Dam to safely pass emigrating Chinook salmon.
    - Construction of a sorter/separator at Leaburg Dam on the McKenzie River to create a natural fish sanctuary above Leaburg Dam.
    - Completion of habitat mitigation projects below Cougar Dam.

1.4 Project Location

The Project is located within the Cougar Creek-South Fork McKenzie River Sub-watershed (FIGURE 6). The Project area encompasses the lower 4.2 miles of the South Fork McKenzie River from the base of Cougar Dam to the confluence with the McKenzie River and is approximately 780 acres in size (FIGURE 7). It includes two large alluvial valleys, separated by a transport reach, with another transport reach right below Cougar Dam (FIGURE 8) as well as some access roads and staging sites. The Lower Alluvial Valley is from river mile 0 to 2, the Lower Transport Reach is from river mile 2 to 2.5, the Upper Alluvial Valley is from river mile 2.5 to 3.5, and the Upper Transport Reach is from river mile 3.5 to 4.2. The eastern portion of the Project area is bound by Forest Road 1900-410, the western portion is bound by Forest Roads 1900 and 1900-408, the northern portion is bound by Forest Road 1900-400 and Delta Campground, and the southern portion is bound by Cougar Dam. Most of the Project area is under USFS ownership, except for approximately 40 acres owned by the USACE. The legal location is: T16S, R4E, S23 and S24; T16S, R4.5E, S24 and S25; T16S, R5E, S19, S30, and S31. The center of the Project area is at 44° 09' 13.89" N, 122° 15' 32.16"W.

FIGURE 6. SUB-WATERSHEDS OF THE SOUTH FORK MCKENZIE RIVER WATERSHED. THE COUGAR CREEK-SOUTH FORK MCKENZIE RIVER SUB-WATERSHED ENCOMPASSES THE ENTIRE SOUTH FORK BELOW COUGAR DAM.



This comprehensive stream design for approximately 4.2 miles of the lower South Fork McKenzie River has been developed by the WNF and U.S. Forest Service TEAMS Enterprise Unit, in coordination with the MWC. This Project is an important part of regional efforts to restore habitat for spring Chinook salmon and bull trout in the Willamette River Basin. The Project will also provide important benefits to other native fish and wildlife and water quality. The Project is designed to rehabilitate to the maximum extent practicable the physical, chemical, and biological processes that are impaired by Cougar Dam, legacy levee, riprap, and fill material, and by logging and stream clean-out in the past century. The Project will include the removal of levee, riprap, and fill material, aggradation of currently incised channels, construction of a new channel network utilizing relic channels where they exist, addition of large woody material and sediment, riparian planting, and noxious weed treatment.

FIGURE 7. PROJECT BOUNDARY WITH ROADS AND LAND OWNERSHIP.

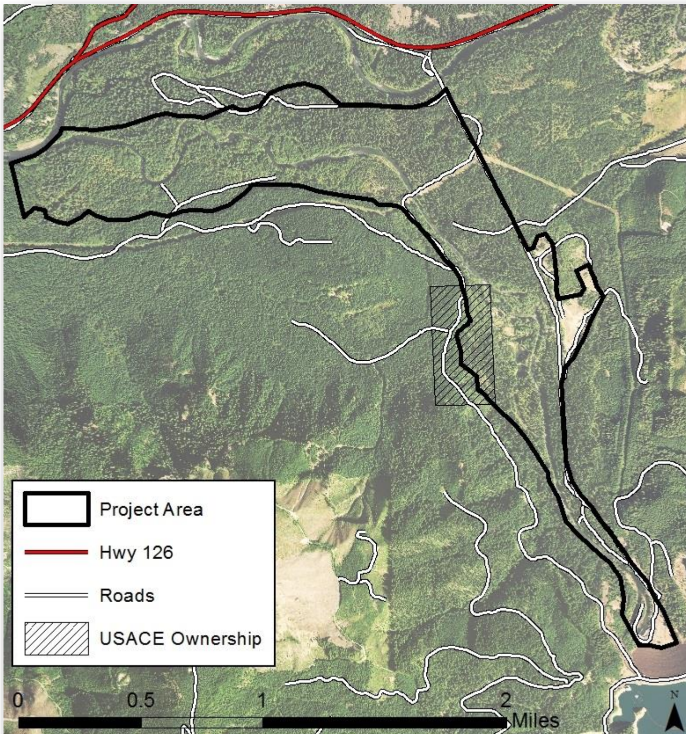
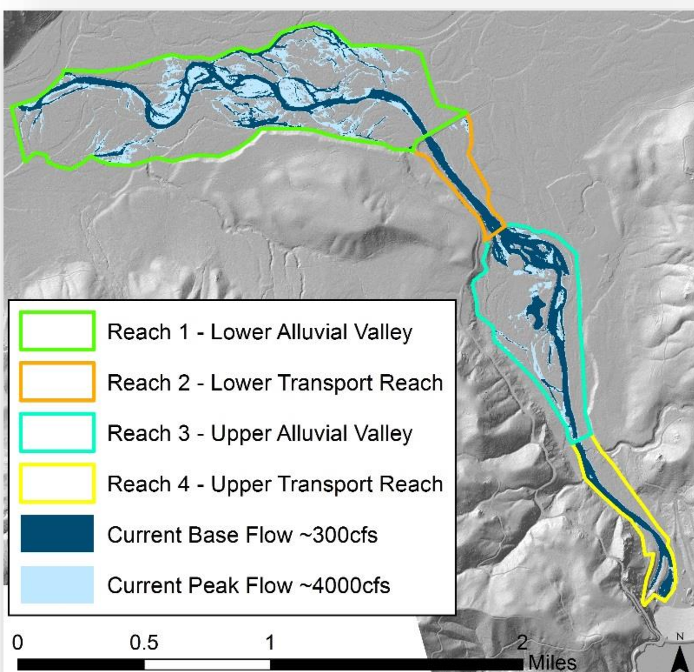


FIGURE 8. GEOMORPHIC REACHES WITHIN THE PROJECT AREA.



2.0 DEVELOPMENT AND PLANNING

The WNF and MWC have been working as partners on various restoration projects throughout the McKenzie River Sub-basin for the past decade, including:

- Upper McKenzie Aquatic Restoration Project (2005-2006)
- Upper South Fork McKenzie River Aquatic Enhancement Project (2007-2008)
- Middle McKenzie Side Channel Enhancement Project (2009-2012)
- Deer Creek Floodplain Enhancement Project (2015-2016)

In 2013, the partners began evaluating potential restoration alternatives and developing a restoration design to restore approximately 4.2 miles of the lower South Fork McKenzie River.

This Project design is funded primarily through a technical assistance grant from the Oregon Watershed Enhancement Board and through in-kind contribution of Willamette and Deschutes National Forest staff time and resources. The Eugene Water & Electric Board (EWEB) has also been a supporter and funder of project planning due to the implications for water quality and watershed health related to municipal drinking water. The following core design team consists of:

- KATE MEYER, FISHERIES BIOLOGIST, WILLAMETTE NATIONAL FOREST
- BONNY HAMMONS, DISTRICT HYDROLOGIST, WILLAMETTE NATIONAL FOREST
- JOHAN HOGERVORST, FOREST HYDROLOGIST, WILLAMETTE NATIONAL FOREST
- PAUL POWERS, FISHERIES BIOLOGIST, DESCHUTES NATIONAL FOREST
- JARED WEYBRIGHT, PROJECTS COORDINATOR, MCKENZIE WATERSHED COUNCIL
- BRIAN BAIR, FISHERIES BIOLOGIST, USFS TEAMS ENTERPRISE UNIT
- GREG ROBERTSON, FISHERIES BIOLOGIST, USFS TEAMS ENTERPRISE UNIT
- CORINNE MAZULLO, ENGINEER, USFS TEAMS ENTERPRISE UNIT

Many other people have assisted with Project development, including:

- Ruby Seitz, District Wildlife Biologist, Willamette National Forest
- Penny Harris, Wildlife Technician, Willamette National Forest
- Ray Rivera, District Fisheries Biologist, Willamette National Forest
- Doug Shank, Soil Scientist, Willamette National Forest
- Cara Kelly, Archeologist, Willamette National Forest
- Burt Thomas, Botanist, Willamette National Forest
- Jenny Lippert, Forest Botanist, Willamette National Forest
- Dave Sanders, Recreation Planner, Willamette National Forest
- Mei Lin Lantz, Fuels Specialist, Willamette National Forest
- Kenny Gabriel, Engineer, Willamette National Forest
- Elysia Retzlaff, NEPA Planner, Willamette National Forest

In 2016, the USFS Pacific Northwest Region Restoration Services Team in collaboration with WNF staff will be developing a robust revegetation plan that will include soil rehabilitation, replanting, seeding, mulching, and noxious weed treatment.

This Project is intended to be implemented in two phases over two to four years with the first phase primarily working in the Lower Alluvial Valley and the second phase working the Lower Transport Reach, Upper Alluvial Valley, and the Upper Transport Reach. This multi-phase approach is meant to accommodate the large scope of the Project, funding cycles, and seasonal fish and wildlife restrictions.

3.0 COMPLIMENTARY RESTORATION EFFORTS

The holistic watershed-scale restoration approach currently underway in the South Fork McKenzie River Watershed is part of a coordinated long-term strategy to establish and maintain viable fish and wildlife populations by restoring and maintaining conditions that contribute to high quality habitat. The breadth of projects currently underway or that have been completed span broad areas of focus including:

- Riparian and aquatic habitat enhancement
- Fish passage improvement
- Environmental flow and stream temperature restoration
- Vegetation and fuels management
- Recreation management
- Road maintenance and decommissioning
- Planning, monitoring, evaluation, and research

4.0 DESIRED FUTURE CONDITION

In order to fully restore the lower South Fork McKenzie River, Cougar Dam would need to be removed in addition to removal of levee, riprap, and fill material, aggradation of currently incised channels, construction of a new channel network, and addition of large woody material and sediment. Since dam removal is not an option at this time, we intend to restore physical, chemical, and biological processes to the extent practicable by manually supplying wood and sediment blocked by the dam and working with the USACE to release higher peak flows. The desired future condition, therefore, is to have a well-functioning channel network and floodplain within the alluvial valleys of the lower South Fork under different flow, sediment, and wood supply regimes. A well-functioning channel network and floodplain will provide high quality native fish and wildlife habitat, a diverse native plant community, increased water storage, and excellent water quality.

This project is designed to reverse, to the extent practicable, the effects of altered flow, sediment, and wood supply and the historic channelization and subsequent incision that has led to the degradation of habitat in the lower South Fork. This restoration design utilizes a process-based approach, through which the changes proposed will place the Project on a trajectory towards recovery through natural stream evolution and processes rather than a static defined pattern, profile, and dimension. For the alluvial valleys, the desired future condition we are seeking is a relatively dynamic stream network fully connected to the floodplain that is able to function under modified flow, sediment, and wood supply regimes.

4.1 Disturbed Reference Reach

A disturbed reference reach can be found at river mile 1.0 to 1.2 in the Lower Alluvial Valley (FIGURE 9). This reach still lacks large wood and a sediment supply, but channels are relatively dynamic and connected to the floodplain. At this location, nearly the whole valley floor is wetted at some point in the year, which is not the case in most other areas of the Project. Recent large wood inputs at the upper end of the reach have slowed stream energy causing deposition of sediment and reconnection to the floodplain on river right (FIGURE 10 AND FIGURE 11). A large logjam at the upper end is creating deep pools, habitat complexity, and cover (FIGURE 12). Spawning-sized gravels are being sorted within floodplain side channels and fish are utilizing these areas for redd construction (FIGURE 13). There are complex, braided channels through the floodplain that are wetted at base flow (FIGURE 14), providing important thermal refugia for fish and wildlife. Riparian vegetation consists of mostly native species, including sedges, willow, alder, and cottonwood (FIGURE 15).

Using the disturbed reference reach as an indicator of potential conditions and response to disturbance, the desired future condition for the alluvial valleys includes:

- numerous off-channel habitats and refuge during a range of flows
- abundant deep pools,
- abundant large woody material and fine organic matter,
- abundant gravels and areas of fine sediment deposition,
- channel migration/avulsions,
- areas of bank erosion/undercutting, and
- mid-channel bars and vegetated islands.

Having multiple flow paths active at a range of flows will maintain a more natural, dynamic channel pattern with increased sinuosity and decreased slope. This will facilitate access to both the existing relic channel paths and floodplain within the alluvial valleys, along with encouraging gravel deposition for fish spawning. Instream habitat will be complex and diverse and will include cover, pools, off channel habitats, and ample refugia. Groundwater flow paths and hyporheic exchange will be restored by reconnecting the channels to the floodplain. While the desired future condition includes complex aquatic habitats, it will also include features and flow paths that are transient. Features at any given location will be prone to development or abandonment during subsequent high water events.

FIGURE 9. LOCATION OF DISTURBED REFERENCE REACH (IN RED) WITHIN THE LOWER ALLUVIAL VALLEY.

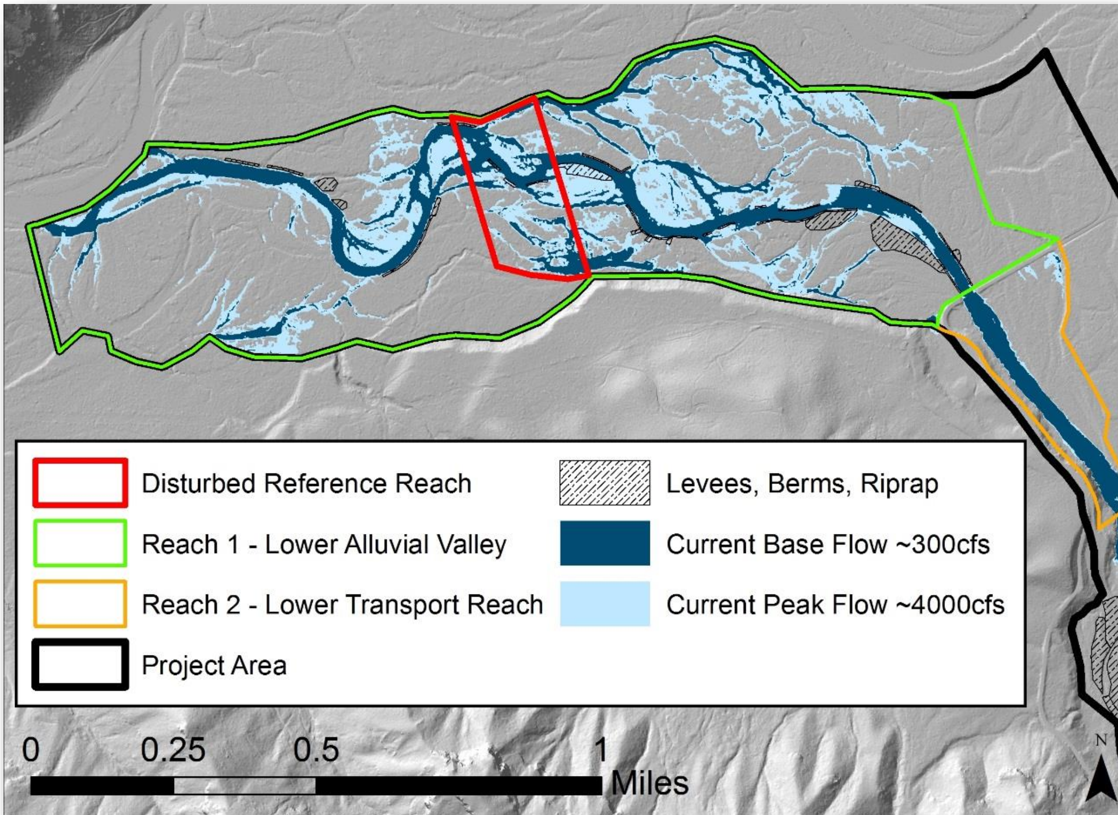


FIGURE 10. UPPER END OF DISTURBED REFERENCE REACH (LOOKING DOWNSTREAM) WHERE RECENT WOOD INPUTS HAVE CAUSED SEDIMENT DEPOSITION AND FLOODPLAIN RECONNECTION.

FIGURE 11. UPPER END OF DISTURBED REFERENCE REACH (LOOKING UPSTREAM) WHERE RECENT WOOD INPUTS HAVE CAUSED SEDIMENT DEPOSITION AND FLOODPLAIN RECONNECTION.

FIGURE 12. LOGJAM AT UPPER END OF DISTURBED REFERENCE REACH CREATING DEEP POOLS, CHANNEL COMPLEXITY, AND COVER.

Figure 13. Sorting of gravels in Floodplain side channels of disturbed reference reach.

Figure 14. Complex, braided channels through floodplain of disturbed reference reach.

FIGURE 15. NATIVE RIPARIAN VEGETATION FOUND IN DISTURBED REFERENCE REACH.

4.2 Sediment Regime

Coarse and fine sediment routed from the upper South Fork McKenzie River Watershed and tributaries are now deposited in Cougar Reservoir. There is one small tributary, Cougar Creek, which enters the South Fork below Cougar Dam and is the sole source of sediment input aside from channel migration. In order to maintain a relatively dynamic, well-functioning floodplain with important habitat features, an additional source of sediment is needed.

To determine the annual quantity of sediment blocked by the dam, reference and current sediment yields for the High Cascades and West Cascades geologic terrain of the upper McKenzie River were calculated by Stillwater Sciences (2006) and ranged from 8-23 tons $km^{-2}y^{-1}$ to 12-22 tons $km^{-2}y^{-1}$, and 66-268 $km^{-2}y^{-1}$ to 181-347 $km^{-2}y^{-1}$, respectively. The yield calculations were estimated by sediment production and storage estimates by process domains, extrapolation of sedimentation rates measured in Smith and Trail Bridge Reservoirs, and by extrapolation of suspended bedload flux rates measured in neighboring watersheds. Because the majority of the South Fork

McKenzie River Watershed is within the West Cascades geologic terrain (FIGURE 2), the lower end of the West Cascades reference range would likely be the starting metric for replacing lost bedload to the riverine system. However, due to the current flow regulation at Cougar Dam, the estimated quantity and larger size classes of reference bedload can no longer be transported. To compensate, the desired annual sediment budget for the lower 4.2 miles of the South Fork was reduced in magnitude by the amount of which peak flows have been reduced (Richards 1982) – a factor of about six. The estimated reduced volume of sediment is on the low end of the calculated reference range and closely matches the lower end of the West Cascades reference range estimate of about 3,000 cubic yards per year.

Although about 70% of the total Project valley length (about 3.7 miles) is within alluvial valleys that were historically dominated by sediment deposition, only about 20% is currently within a depositional zone. The remaining 80% is considered to be dominated by sediment transport due to the channelization and incision that has occurred in the last 80 years. A transport dominant regime moves sediment through with very little deposition or temporary storage. The large substrate sizes (D50 = 128mm) found throughout the mainstem South Fork and major side channels throughout the Project area do not represent the historic or desired sediment size classes conducive to fish spawning and rearing. Based on valley type, historic aerial photos, relic channels, and disturbed reference reach, the majority of the Project area should function as a depositional reach. If the channel were not confined and had access to a well vegetated floodplain, multi-thread channels would meander throughout the historic floodplain areas depositing a well-sorted sediment load made up of much smaller materials. In addition, fines would be deposited on the floodplain rather than in the channel and would promote riparian plant development.

The Project intent is to increase sediment deposition and sorting throughout the Project area. Rather than containing the bedload as a mix within a confined channel, the desired future condition will sort the bedload and deposit the larger gravels, cobbles and small boulders in riffles, the spawning-sized gravels in pool tail outs, and the sands and silts on the floodplains and bars. Sediment deposition occurring at a range of flows will support riparian plant seed propagation on the floodplain and bars as well as helping to retain nutrients, thus supporting macro-invertebrate populations and the aquatic food web.

4.3 Riparian Vegetation

Riparian vegetation is well known to influence stream ecosystems worldwide. In the Pacific Northwest riparian areas are known to regulate channel morphology, stream water temperatures, and nutrient flow (Hetrick et al 1998). It is also well understood that riparian areas play a very large role in the persistence of aquatic ecosystems. The desired future vegetative condition consists of dense and diverse riparian vegetation that extends throughout the reactivated alluvial valleys and provides stream shade, bank and floodplain stability, and riparian habitat for resident and migratory wildlife and allochthonous inputs to the stream. By reconnecting the floodplain and raising groundwater levels, backwater areas and off-channel areas will be restored providing complex habitat for aquatic and terrestrial species. Over time, vegetation communities will represent a diversity of age classes and will change as the stream channels migrate laterally across the floodplain. Species composition will also reflect the higher water table that will result from more frequent floodplain inundation, favoring more wetland and hardwood communities interspersed within mixed conifer stands.

4.4 Large Woody Material

The physical and biological effects of large woody material (LWM) on stream ecosystems has been widely studied. For instance, LWM has been shown to:

- Increase storage and routing of both sediment and organic matter (Smith et al. 1993, Wallace et al. 1995, Gomi et al 2002, Hassan and Woodsmith 2003);
- Modify and maintain channel geomorphology and habitat types important to salmonids (Murphy and Meehan 1991, Nakamura and Swanson, 1993);
- Alter flows by changing velocity and facilitating floodplain connection (Bryant 1983, Everest and Meehan 1981, Harmon et al. 1986);
- Retain smaller organic and dissolved materials important to primary producers (Bilby and Likens 1980, Wallace et al 1995); and
- Lead to increased densities of fish (Roni and Quinn 2001, Bustard and Hawthorne 1975).

Although no data exists to determine historic in-stream LWM densities in the Project area, data from undisturbed reference streams of similar stream types indicate that historic LWM densities were much greater than the current density of less than 20 pieces per mile. Densities for desired in-stream total LWM and key LWM in the Project area can be estimated from Fox and Bolton (2007). The authors suggest that streams in a degraded state "be managed for an interim target at or above the 75th percentile until the basin-scale wood loads achieve these central tendencies". The 75th percentile for West Cascades streams over 30 meters bankfull width is about 3,500 pieces of total wood per mile (at least 4 inches diameter and 6 feet long) and at least 70 pieces per mile of "key" wood with rootwad (at least 24 inches diameter and 50 feet long).

Bair and Robertson from the USFS TEAMS Enterprise Unit have also collected data on reference conditions for West Cascades mid-order streams of similar channel type, riparian eco-class, and elevation to the South Fork. The 75th percentile is approximately 200 pieces per mile (at least 24 inches diameter and 50 feet long).

5.0 GOALS AND OBJECTIVES

Although Cougar Dam presents a major obstacle to floodplain restoration by altering flows and blocking wood, sediment, and nutrients, management actions can significantly improve conditions. The Project goal is to rehabilitate to the maximum extent practicable the physical, chemical, and biological processes that support a healthy, resilient ecosystem and sustain habitat conditions needed to improve productivity for spring Chinook salmon, bull trout, Pacific lamprey, rainbow trout, cutthroat trout, western pond turtle, and other native species. Because Cougar Dam is the root cause of impaired processes and dam removal is not an option at this time, we propose to manually restore processes (e.g. wood, sediment, and nutrient delivery and storage; stream flow and flood storage; channel, floodplain, and habitat dynamics). We expect to achieve the following objectives:

1. Within the Lower Alluvial Valley, increase area of floodplain inundation and secondary channel habitat during annual peak flow (approx. 4,000 cfs) and during base flow (approx. 300 cfs) by at least 40% within 5 years of Project completion.
2. Within the Upper Alluvial Valley, increase area of floodplain inundation and secondary channel habitat during annual peak flow (approx. 4,000 cfs) and during base flow (approx. 300 cfs) by at least 100% upon Project completion.
3. Within primary channels in alluvial valley reaches, increase key LWM density to at least 200 pieces per mile (at least 24 inches diameter and 50 feet long with rootwad) and small LWM density to at least 400 pieces per mile (at least 12 inches diameter and 25 feet long) upon Project completion.
4. Within secondary channels and floodplain in alluvial valley reaches, increase small LWM density to at least 900 pieces per mile (at least 12 inches diameter and 25 feet long) upon Project completion.
5. Within alluvial valley reaches, increase pool area (% thalweg length) in primary channels from 19-25% to at least 40% within 5 years of Project completion.
6. Within alluvial valley reaches, decrease the mean particle size from cobble dominant (D50 = 128mm) to gravel dominant (D50 = 32-64mm) in primary and large secondary channels within 5 years of Project completion.
7. Increase spring Chinook salmon redd abundance by 25% within 5 years of Project completion.
8. For western pond turtles, create a minimum of 5 ponds or backwater areas at least 0.25 acres in size and at least 6 feet deep that are exposed to full sun for most of the day and place several pieces of LWM in and around each pond. Create 1-2 silt/clay substrate mounds per pond (10’ x 10’ x 2’ deep) above the 10-year floodplain in south-facing sunny areas next to ponds. Seed with native, weed-free grasses.

9. For waterfowl, create 1-2 ponds or backwater areas at least 1.5 acres in size with at least 1 small island and several pieces of floating large wood upon Project completion.
10. Create numerous shallow, ephemeral pools on floodplain for amphibian breeding upon Project completion.

These objectives establish specific, measureable, achievable, realistic, and time-bound (SMART) metrics to determine Project success. They will be monitored both immediately following implementation and over the long term.

6.0 EXISTING CONDITIONS

The existing condition analysis was completed using a combination of site visits, field surveys, extensive review of historic aerial photos, satellite imagery, Light Detection and Ranging (LiDAR) imagery and elevational data, USFS Stream Inventory data, USGS stream gauge data, and previous existing condition analyses as part of the South Fork Watershed Analysis (1994) and Update (2010).

The earliest aerial photos show that extensive timber harvest, road building, and stream clean-out of LWM within the riparian area and floodplain began prior to 1946 (FIGURE 16). Because wood was very likely being cleared out of the channel for timber and navigation, the channel in the 1946 photo may have already began to incise and lose connectivity with the floodplain. The dense forest makes it difficult to see smaller secondary channels in the floodplain, but a bare earth LiDAR image in which vegetation can be removed to elucidate fine details in topography reveals a complex network of channels across the alluvial valleys (FIGURE 17).

FIGURE 16. AERIAL PHOTO OF THE PROJECT AREA TAKEN SEPTEMBER 12, 1946.

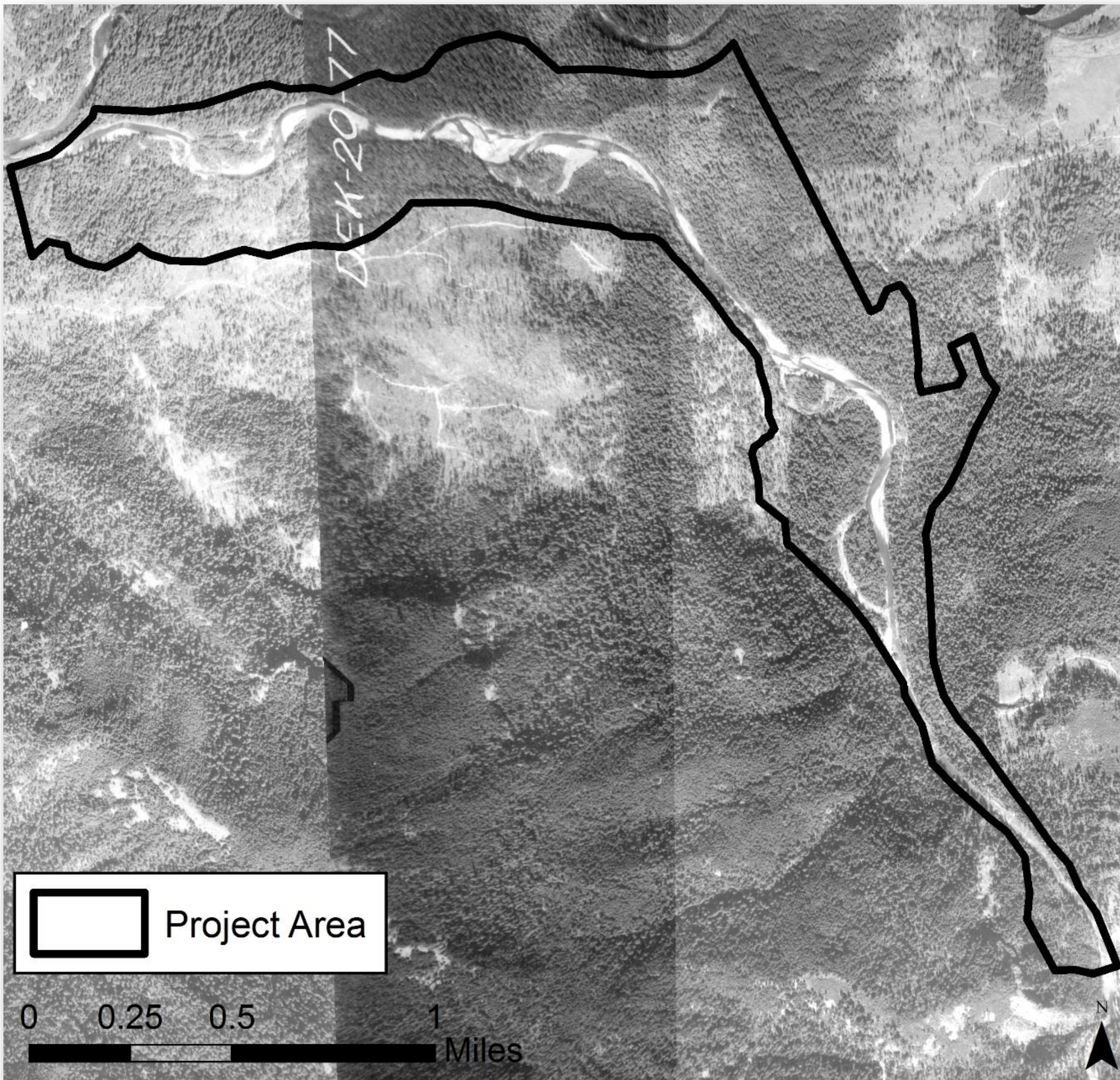
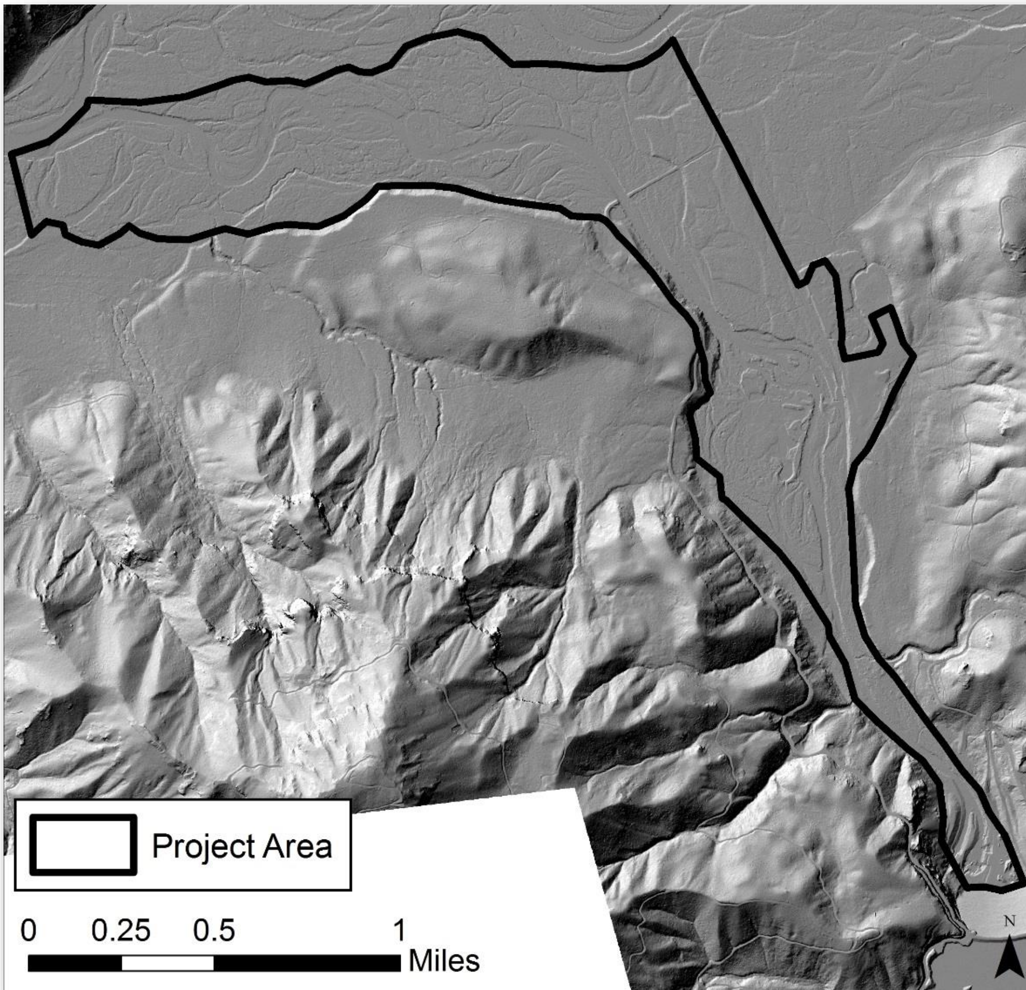


FIGURE 17. BARE EARTH LIDAR IMAGE OF THE PROJECT AREA TAKEN AUGUST 22, 2009.



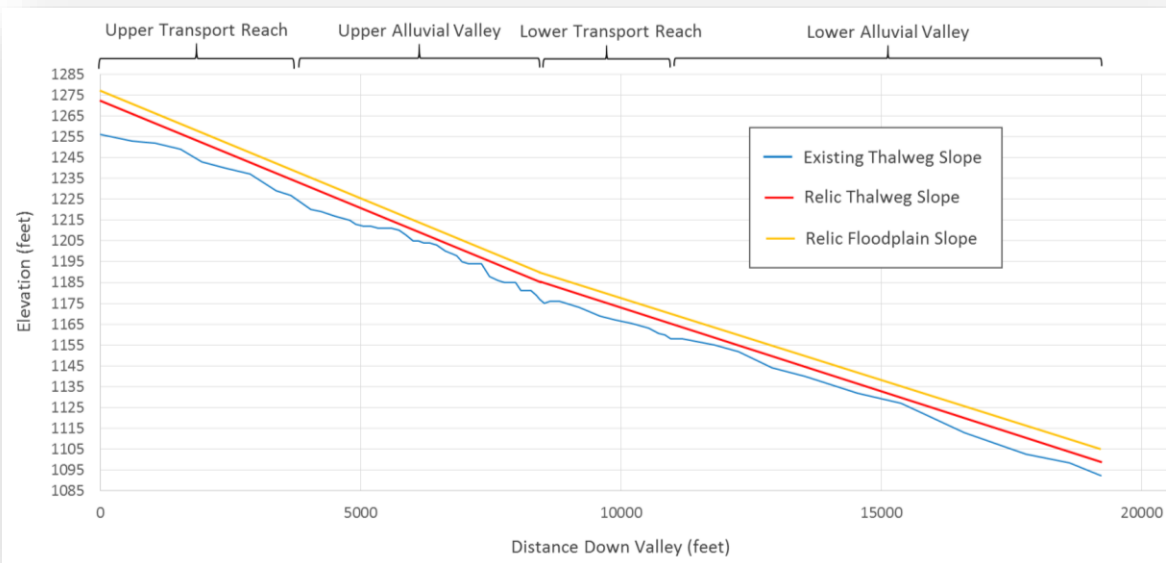
The entire Project area was extensively surveyed to determine the extent and location of anthropogenic features such as levees, riprap, and fill material. The definitions used here are as follows:

- *Levee* – a man-made, linear, earthen structure built parallel to the river, above natural bank height, designed to prevent flooding of adjacent areas
- *Riprap* – rock or other material used to armor streambanks against scour and erosion
- *Fill* – sediment placed to raise the ground elevation of a non-linear area or to plug entrances to relic side channels

The result of our survey and analysis indicate that about 28 acres of these constructed features exist in the Project area (FIGURE 5). These features, in addition to the historic removal of wood and lack of wood and sediment supply have concentrated flow in one primary channel, causing incision of that channel.

To determine the current extent of channel incision and floodplain disconnection throughout the Project area, we conducted a longitudinal profile analysis using a bare earth LiDAR 1-meter Digital Elevation Model (DEM). Using elevations from the DEM and georeferenced features in the field, we built a longitudinal profile with (1) current thalweg slope, (2) relic thalweg slope, and (3) relic floodplain slope (FIGURE 18). From these slopes, we are able to determine where incision has occurred and the approximate depth of incision. According to the longitudinal profile and field-verification, the mainstem channel is incised throughout the Project area, some areas more than others.

FIGURE 18. LONGITUDINAL PROFILE OF THE PROJECT AREA REVEALING APPROXIMATE LOCATION AND DEPTH OF CHANNEL INCISION [I.E. DIFFERENCE BETWEEN EXISTING (BLUE) AND RELIC (RED) THALWEG SLOPES].



6.1 Lower Alluvial Valley (River Mile 0 to 2)

The Lower Alluvial Valley is about 1.6 miles long (2 miles thalweg length), with a valley slope of about 0.8% and a thalweg slope of about 0.6%. Mainstem sinuosity is 1.3 and bankfull width ranges from 109-252 feet. Pool area (percent of thalweg length) is very low – about 19% – and average pool spacing is about 1,965 feet. LWM density is about 7 pieces per mile at least 12 inches in diameter and 25 feet long and about 3 pieces per mile over 24 inches in diameter and 50 feet long. Sediment is dominated by cobbles in both pools and riffles (D50 = 90-128mm). Reach parameters are shown in TABLE 1.

TABLE 1. GEOMORPHIC AND CHANNEL PARAMETERS FOR EACH REACH OF THE PROJECT AREA.

Reach Parameter	Lower Alluvial Valley	Lower Transport Reach	Upper Alluvial Valley	Upper Transport Reach
Reach Location (River Mile) (LiDAR)	0.0-2.0	2.0-2.5	2.5-3.5	3.5-4.2
Thalweg Length (mi) (LiDAR)	2.0	0.5	1.0	0.7
Valley Slope (LiDAR)	0.8%	0.8%	1.0%	0.7%
Thalweg Water Surface Slope (LiDAR)	0.6%	0.8%	0.9%	0.7%
Sinuosity (LiDAR)	1.3	1.0	1.1	1.0
Width of Active Floodplain (ft) (LiDAR)	3,500	200	2,000	250
Bankfull Average Width (ft) (2005 Survey)	157	127	132	108
Bankfull Width Range (ft) (2005 Survey)	109-252	99-153	124-145	101-114
Bankfull Average Depth (ft) (2005 Survey)	4.6	No Data	4.9	5.2
Bankfull Depth Range (ft) (2005 Survey)	4.2-5.0	No Data	3.5-6.5	4.7-5.5
Bankfull Average Width/Depth Ratio (2005 Survey)	34	No Data	27	21
Pool Area (% of thalweg length) (2005 Survey)	19%	15%	25%	10%
Average Pool Spacing (ft) (2005 Survey)	1,965	2,264	1,055	1,287
Estimated Wetted Channel Area (acres) at Base Flow (about 300cfs)(River Bathymetry Toolkit)	53	10	33	14
Estimated Wetted Channel Area (acres) at Peak Flow (about 4000cfs)(River Bathymetry Toolkit)	132	11	50	15
Instream LWD All Classes (per mi)(>12" x 50'; 2005 Survey)	7	8	10	20
Instream LWD Medium/Large Classes (per mi)(>24" x 50'; 2005 Survey)	3	0	3	7
Mean substrate size range/D50 (mm) (measured in riffles)	90-128	N/A	90-128	180-256

In the Lower Alluvial Valley, riprap and fill cover approximately 8 acres (FIGURE 19). Due to lack of LWM and sediment, flow is concentrated in one primary channel and incision of this channel is occurring, but only moderately. According to our longitudinal profile analysis, the channel is incised about 2-7 feet (FIGURE 20). The Lower Alluvial Valley is about 392 acres. A floodplain inundation model, called River Bathymetry Toolkit, was used to estimate wetted area at various flow stages (McKean et. al. 2009). Estimated wetted channel area during base flow (about 300 cfs) is approximately 53 acres and about 132 acres at annual peak flow (about 4,000 cfs)(FIGURE 19). Under current conditions, only about 34% of the historic floodplain is being utilized.

This data suggests that high flows and associated excess stream power are mostly contained in a primary channel with minimal energy dissipation, resulting in channel incision, disconnection from the floodplain, simplified habitat, and a lower valley wide groundwater table. Much of the primary and secondary channels are dominated by long, shallow riffles with minimal habitat complexity (FIGURE 21 AND FIGURE 22). Portions of this reach function more as a transport reach than a depositional reach, as evidenced by coarse substrate.

Reach data reveals degraded conditions, but portions of the reach are relatively dynamic and connected to the floodplain. The disturbed reference reach (see Section 4.1) within the Lower Alluvial Valley is an indication that with sediment and wood input, recovery of important habitat features and floodplain connectivity is easily attainable without having to manually aggrade the mainstem channel.

FIGURE 19. EXISTING CONDITIONS WITHIN THE LOWER ALLUVIAL VALLEY.

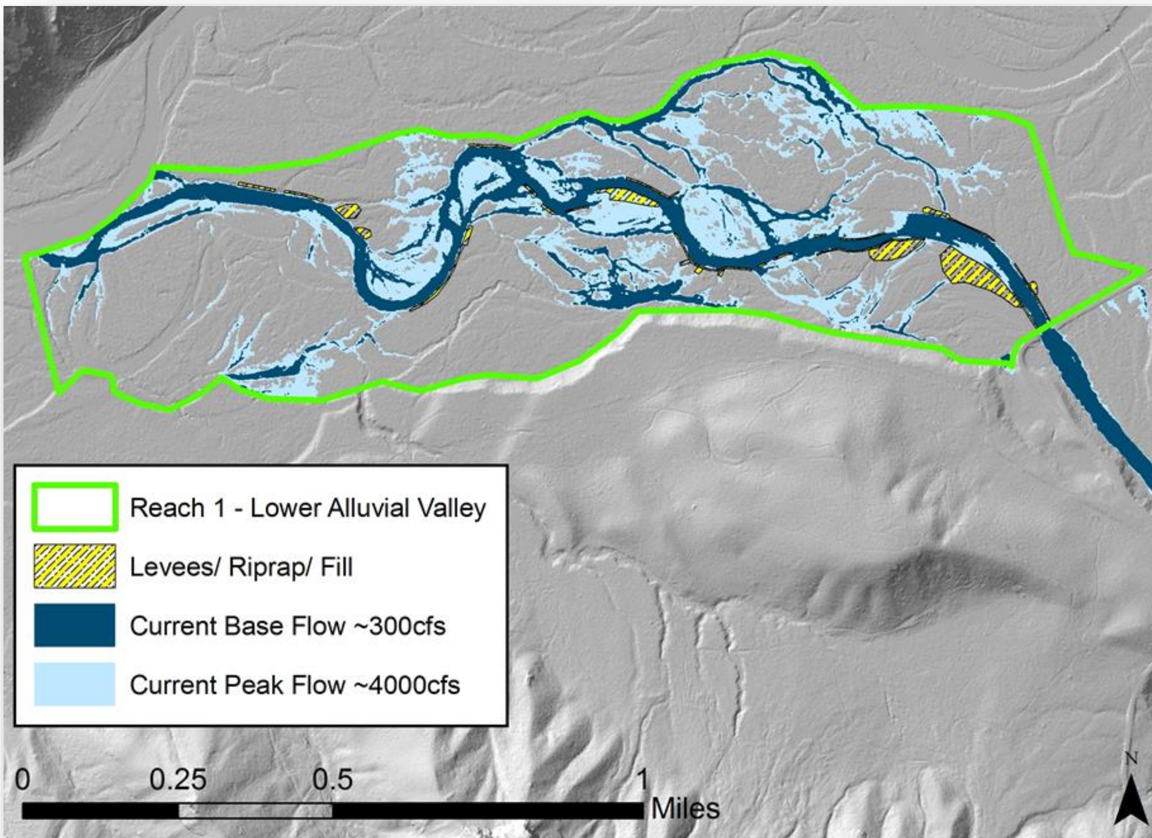


FIGURE 20. LONGITUDINAL PROFILE OF LOWER ALLUVIAL VALLEY REVEALING APPROXIMATE LOCATION AND DEPTH OF CHANNEL INCISION [I.E. DIFFERENCE BETWEEN EXISTING (BLUE) AND RELIC (RED) THALWEG SLOPES].

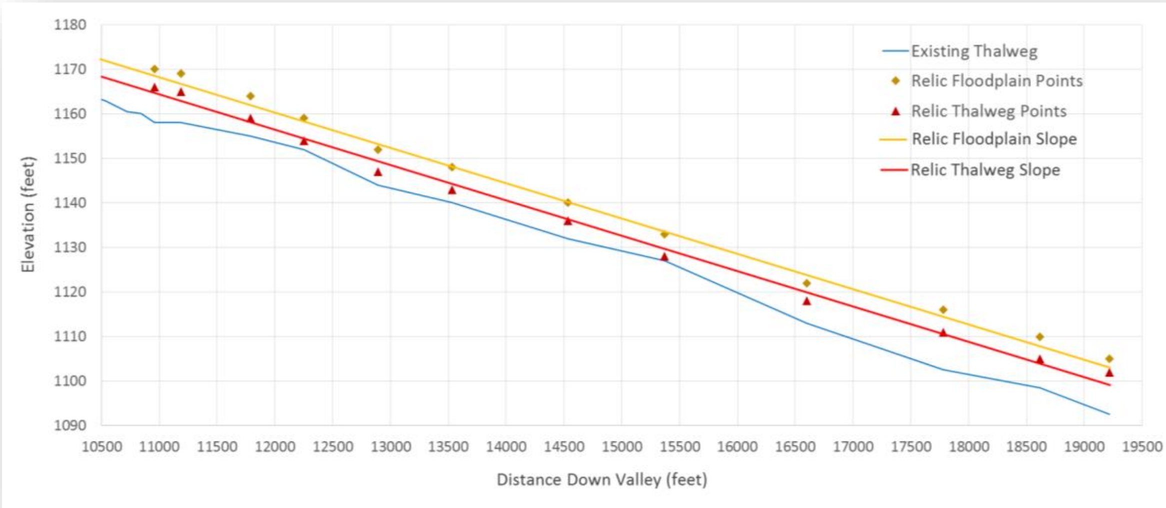


FIGURE 21. PHOTO OF COMMON PRIMARY CHANNEL CONDITIONS IN THE LOWER ALLUVIAL VALLEY – LONG, SHALLOW RIFFLES WITH NO WOOD AND COARSE SEDIMENT.

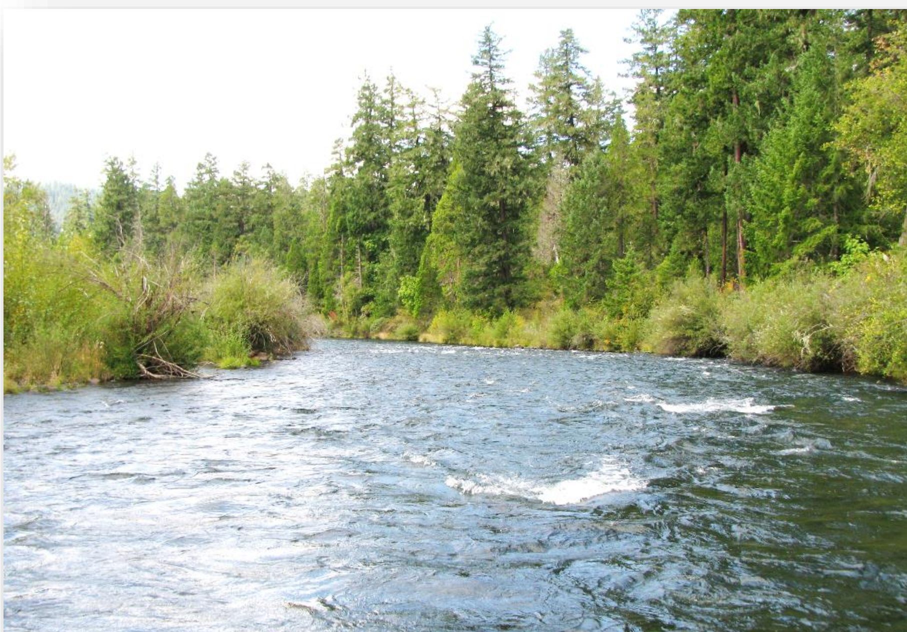


FIGURE 22. PHOTO OF COMMON SECONDARY CHANNEL CONDITIONS IN THE LOWER ALLUVIAL VALLEY – LONG, SHALLOW RIFFLES WITH MINIMAL WOOD AND COARSE SEDIMENT.

6.2 Lower Transport Reach (River Mile 2 to 2.5)

The Lower Transport Reach is about 0.5 miles long, with a valley and thalweg slope of about 0.8% (FIGURE 23). Mainstem sinuosity is 1.0 and bankfull width ranges from 99-156 feet. Only one pool exists at the very upper end for a total pool area (percent thalweg length) of about 15% and LWM density is about 8 pieces per mile of the small size class (at least12 inches in diameter and 25 feet long). Based on visual observations, sediment is dominated by cobbles. Additional reach parameters are shown in TABLE 1.

At the very upper end of the reach, the geology forms a natural pinch point forcing the stream to narrow. Historic terraces can be seen on river right but the area of recent (pre-dam) floodplain is minimal. There was more floodplain connectivity at the lower end of this reach on river right, but construction of Forest Road 19 and the bridge across the South Fork has effectively eliminated the potential for restoration of floodplain connectivity.

Despite its relatively low gradient, this area acted and still acts more as a transport reach. The flow is concentrated in a single, narrow channel, which has caused substantial incision. According to our longitudinal profile analysis, the channel is incised about 6-9 feet (FIGURE 24). This reach functions largely as a transport reach, with very little opportunity for sediment storage.

FIGURE 23. EXISTING CONDITIONS WITHIN THE LOWER TRANSPORT REACH.

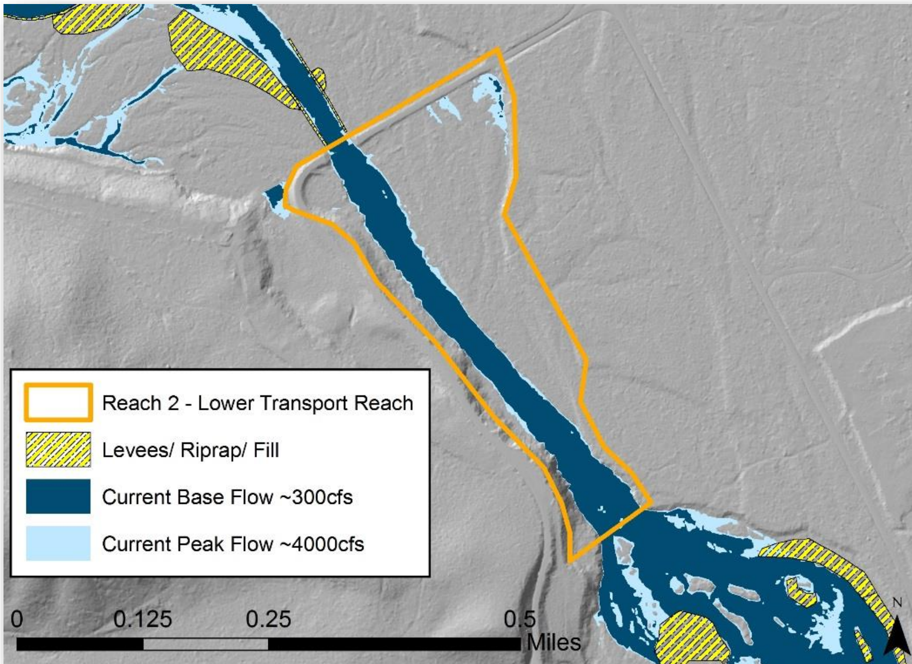
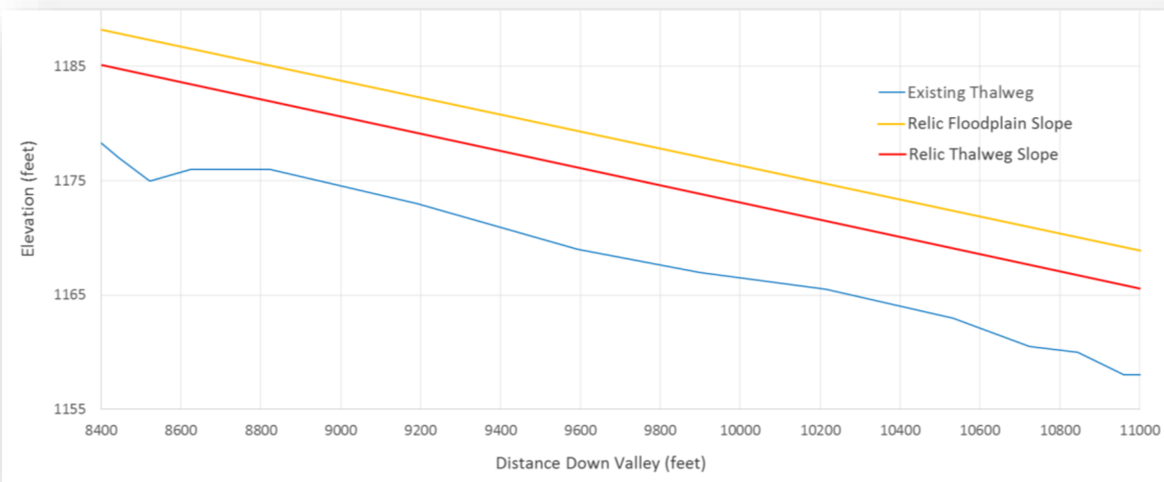


FIGURE 24. LONGITUDINAL PROFILE OF LOWER TRANSPORT REACH REVEALING APPROXIMATE LOCATION AND DEPTH OF CHANNEL INCISION [I.E. DIFFERENCE BETWEEN EXISTING (BLUE) AND RELIC (RED) THALWEG SLOPES].

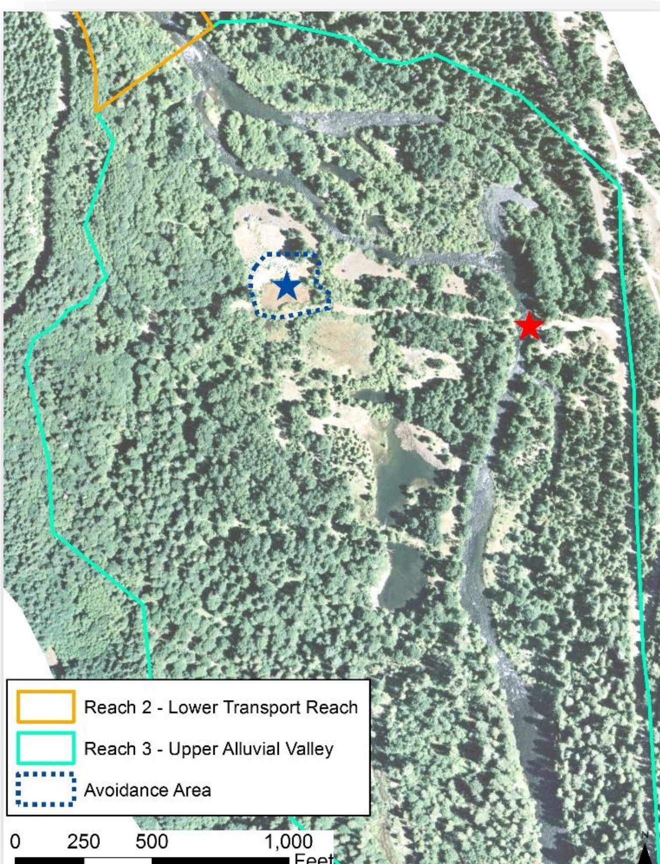


6.3 Upper Alluvial Valley (River Mile 2.5 to 3.5)

6.3.1 Management History

The Upper Alluvial Valley has a unique history of manipulation with most alterations associated with the construction of Cougar Dam, which began in May of 1956. The dam became operational for flood control in November 1963 and was fully operational for power generation in March 1964. The exact dates of alterations to the Upper Alluvial Valley are unclear. Aerial imagery that was analyzed as part of the South Fork Watershed Analysis (1994) shows this reach of the South Fork being channelized with levees and fill material at some point after 1959. The initial purpose of the channelization was to straighten and narrow the mainstem channel in order to build a temporary bridge (FIGURE 25). Historical references indicate that the Upper Alluvial Valley was used as an equipment staging area for dam construction activities. It is safe to say this would not have occurred until after 1959 when the mainstem was channelized, isolating the floodplain from the river to dry.

FIGURE 25. AERIAL PHOTO OF UPPER ALLUVIAL VALLEY TAKEN IN 2009 SHOWING LOCATION OF PROPOSED BRIDGE (RED STAR), FORMER EQUIPMENT STAGING SITES (UNVEGETATED AREAS), REMEDIATION POND (BLUE STAR), AND AVOIDANCE AREA.



After 1959, the new staging area served two main purposes. The north end of the site was used for crushing rocks, presumably to create fill for the dam. The remnants of this activity are still highly visible today (FIGURE 25). Based on information gathered from conversations with USFS employees that were around during construction of the dam, the central part of the site was used as an equipment fueling site, an oil draining site, and as an area where excess concrete was deposited. Three large ponds were also dug around this time. U.S. Fish and Wildlife Service (USFWS) records indicate that the ponds were dug between 1958 and the completion of the dam in 1964. There is currently no information on the original purpose for digging the ponds. There is speculation they were dug as mitigation for habitat lost by construction of the dam.

Until 1991, the ponds were recharged through seepage from the South Fork and occasional high flows from a historic side channel. The USFS first attempted to restore perennial flow to the ponds in 1989 but they were unable to excavate enough material from the historic side channel. The USFS developed another project to restore these flows again in 1992. This project required one to four feet of excavation in the historic channel above the ponds and one to six feet in the channel below the ponds. The plan also called for riparian planting, the placement of large wood in the new channels, and the excavation of one additional pond in the north part of the site.

Work began on July 27, 1992 with the excavation of the side channel above the pond. During the next two days the contactor was able to finish the upper and lower side channels which connected the ponds through to the South Fork. On July 30, 1992 the contractor was digging a test hole at the new pond site to determine the depth of groundwater. After just one bucketful of soil the crew smelled diesel. Upon digging to groundwater they discovered an oily sheen on the water. Work on the habitat improvement project ceased after this discovery and the contract was cancelled.

The discovery of the oil by the contractors immediately triggered a clean-up response. The first stage in the clean-up was determining who was responsible. Once it was established that the hydrocarbons present were related to the construction of Cougar Dam the USACE took full responsibility for the clean-up effort. On August 4th, 1992, 14 test pits were dug in an attempt to discover the extent of the contamination. On September 3rd, 1992, 8 more test pits were dug. In the majority of the pits groundwater was discovered at 2 feet below the surface. Around 6 feet in some of the pits there was a layer of concrete from the dam construction. Samples were taken of the soil and water in each of the pits. Laboratory tests showed that hydrocarbons from oil and gasoline were present in 12 of the 22 pits dug. The results ranged between 6 and 2,550 total petroleum hydrocarbon (TPH) parts per million. With these pits the USACE was able to determine the north, west, and southern extent of the contamination. They continued to be unsure of the eastern edge of the contamination because they were reluctant to dig towards the South Fork. All of this work was conducted by TMC Environmental, Inc. from Eugene, Oregon.

The initial clean-up plan was to excavate the contaminated soil and then use a mobile thermal desorption unit to burn it. This would be done in conjunction with treating the groundwater that seeped out during the excavation. Work on the site began October 18th, 1993. It was quickly discovered that the soil being excavated had too high of a moisture content to burn. To remedy this situation the USACE constructed a containment cell for the soil to the north of the excavation site. The containment cell was 100 feet by 100 feet across and 6 feet deep. It was constructed of 6mm plastic layered three times. This initial clean-up excavated around 2,000 cubic yards of soil. About 500,000 gallons of water were also treated and pumped back into the South Fork. The water treatment was monitored by the Oregon Department of Environmental Quality. Worked ceased on Phase 1 of the clean-up November 5th, 1993. Contaminated soils still existed to the north and east of the site but they could not be excavated at the time because of the risk of contamination to the South Fork. Once this phase was completed the USACE fenced the contaminated area and issued a closure notice.

Phase 2 of the clean-up began in February 1994. The purpose of this phase was to remove the rest of the contaminated soil from north and east of the site. In order to accomplish this the USACE had to reroute the side channel coming out of the ponds to avoid contamination of the South Fork. Excavation work began once the new channel was dug and a protective berm was built between it and the excavation site. During Phase 2, an additional 2,000 cubic yards of soil were removed from the contamination site. The containment cell was expanded as necessary. Phase 2 work was finished in March of 1994.

After Phase 2 the excavated site filled with groundwater creating a new pond. In order to make sure this pond was free of all hydrocarbons the USACE hired AGRA Earth and Environmental, Inc. to treat the water and soil with a petroleum degrading bacteria and nutrients. This bioremediation work happened in December of 1994. The remediation work was a three part process that involved aeration of the pond soils, application of bacteria, and the addition of nutrients. The bacteria involved in the remediation are referred to as a hydrocarbon degrading bacteria. Ammonium nitrate was the nutrient added to the pond sediments during the remediation effort.

The final clean-up work happened between mid-July and mid-August of 1995. The purpose of this work was to remove the containment cell and treat all of the material that had been removed. The exact details of the work that happened during this time are fairly unclear. What can be gathered is that once the material was removed from the containment cell it was taken to the Cougar Dam Maintenance Compound. Once there it was crushed and separated into fine and course material.

It can be assumed from current observations that the containment cell site was filled after its removal and tree planting was done over top of it. There is no indication in our records of what material was used to fill the hole created by the removal of the containment cell. Forest Service records contain some monitoring results dated November 30, 1997. These records indicate that hydrocarbon levels have "plateaued at low but detectable TPH values." The results from this monitoring are difficult to interpret because they offer no information about where samples were taken or with what methods. On October 15th, 2014 surface water samples were collected from the remediation pond. The samples were collected using a sampling pole, stored on ice and sent to TestAmerica and Water Management Labs for analysis. The analytes for hydrocarbons came back non-detect. In December 2014, the USACE collected follow-up soil samples around the remediation pond. The results indicate that no hydrocarbons were detected.

Although recent testing has come back non-detect for hydrocarbons, to reduce the risk of encountering contaminants, we have decided to designate an "avoidance area" around the remediation pond and the former location of the containment cell (FIGURE 25). Within this avoidance area, no material will be excavated. We will also have a contingency plan in place in case contaminants are discovered during implementation.

6.3.2 Channel Morphology

The Upper Alluvial Valley is about 0.9 miles long (1 mile thalweg length), with a valley slope of about 1.0% and a thalweg slope of about 0.9%. Mainstem sinuosity is 1.1 and bankfull width ranges from 124-145 feet. Pool area (percent of thalweg length) is low – about 25% – and average pool spacing is about 1,055 feet. LWM density is about 10 pieces per mile at least 12 inches in diameter and 25 feet long and about 3 pieces per mile over 24 inches in diameter and 50 feet long. Sediment is dominated by cobbles in both pools and riffles (D50 = 90-128mm). Additional reach parameters are shown in TABLE 1.

In the Upper Alluvial Valley, levees, riprap, and fill cover approximately 18 acres (Figure 26). Due to channelization and lack of LWM and sediment, flow is concentrated in one primary channel and incision of this channel is substantial. According to our longitudinal profile analysis, the channel is incised about 3-13 feet (FIGURE 27). The Upper Alluvial Valley is about 148 acres. Estimated wetted channel area during base flow (about 300 cfs) is approximately 33 acres and about 50 acres at annual peak flow (about 4,000 cfs)(Figure 26). Under current conditions, only about 34% of the historic floodplain is being utilized.

This data suggests that high flows and associated excess stream power are mostly contained in a primary channel with minimal energy dissipation, resulting in channel incision, disconnection from the floodplain, simplified habitat, and a lower valley wide groundwater table. Much of the primary and secondary channels are dominated by long, shallow riffles with minimal habitat complexity (FIGURE 28 AND FIGURE 29). Portions of this reach function more as a transport reach than a depositional reach, as evidenced by coarse substrate. In the lower portion of the reach, where the channel is given more space, there is limited deposition of gravels and correspondingly limited active spring Chinook salmon spawning.

FIGURE 26. EXISTING CONDITIONS WITHIN THE UPPER ALLUVIAL VALLEY.

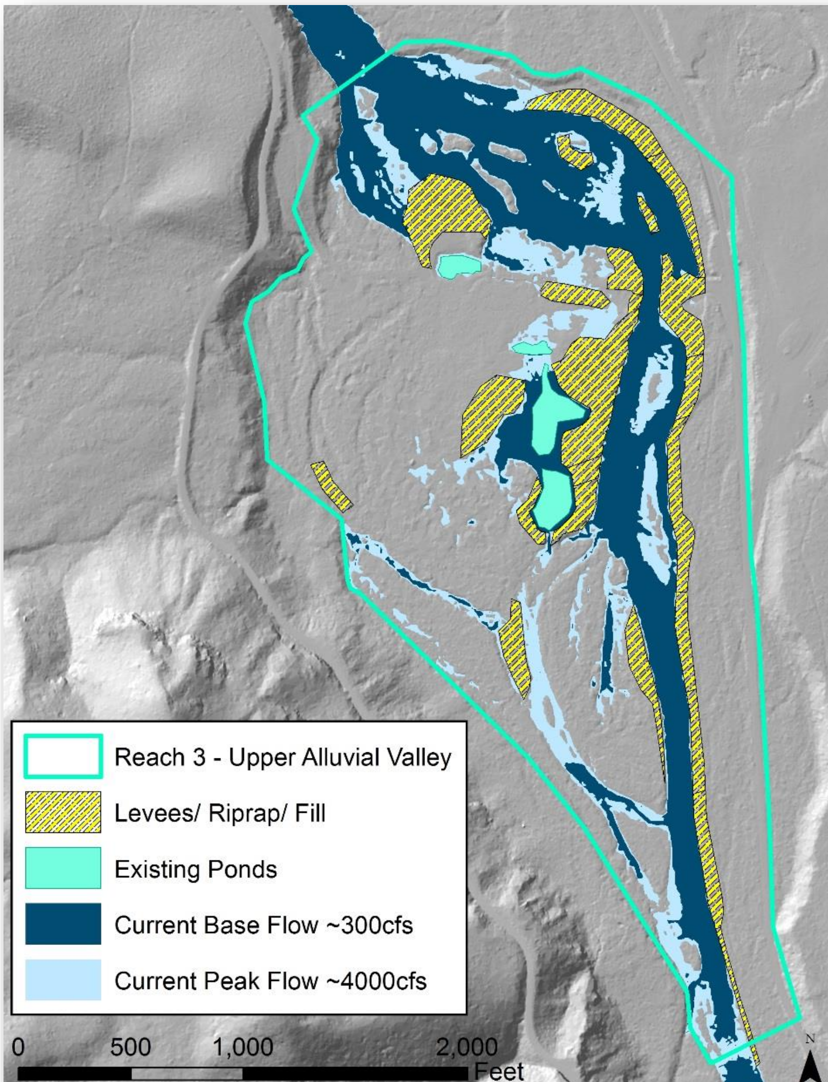


FIGURE 27. LONGITUDINAL PROFILE OF UPPER ALLUVIAL VALLEY REVEALING APPROXIMATE LOCATION AND DEPTH OF CHANNEL INCISION [I.E. DIFFERENCE BETWEEN EXISTING (BLUE) AND RELIC (RED) THALWEG SLOPES].

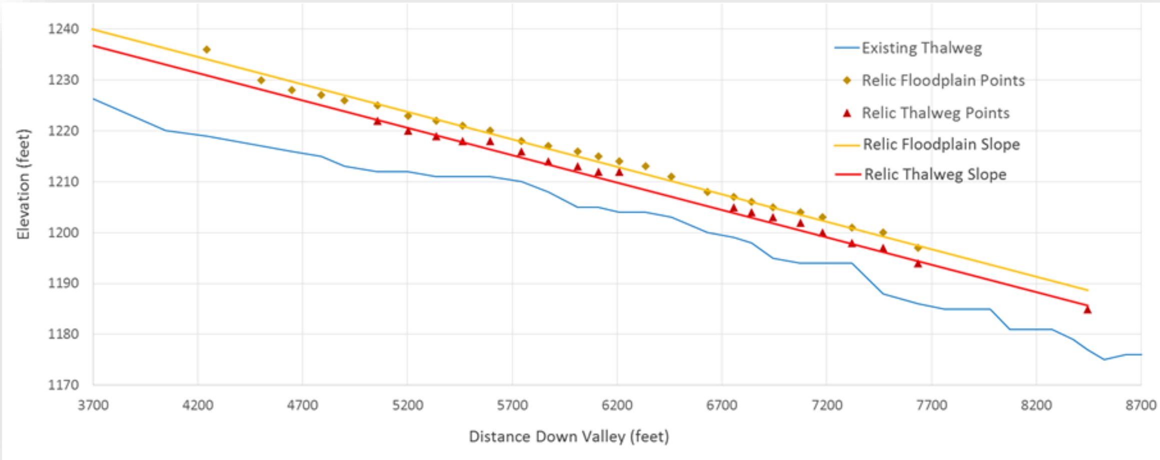


FIGURE 28. PHOTO OF COMMON PRIMARY CHANNEL CONDITIONS IN THE UPPER ALLUVIAL VALLEY – LONG, SHALLOW RIFFLES WITH NO WOOD AND COARSE SEDIMENT.

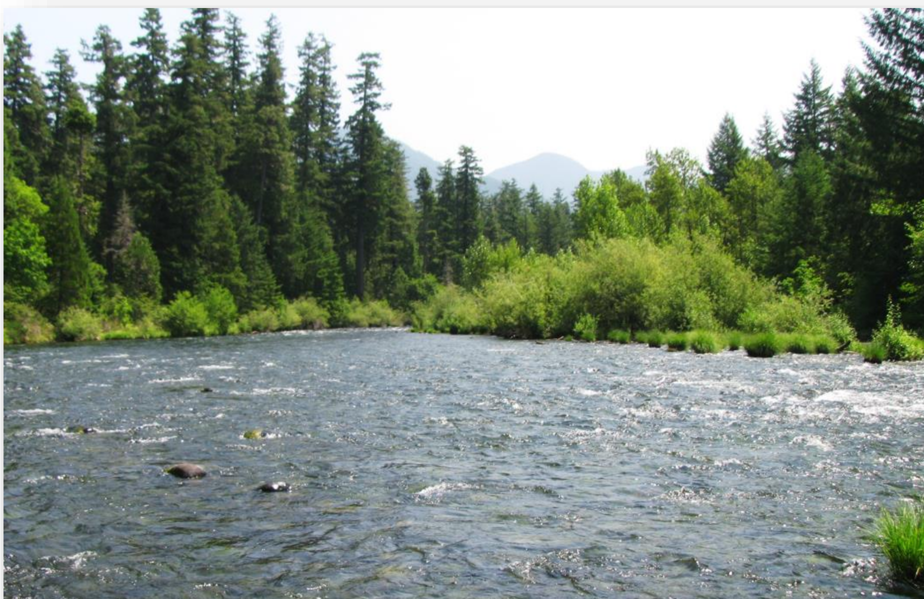


FIGURE 29. PHOTO OF COMMON SECONDARY CHANNEL CONDITIONS IN THE UPPER ALLUVIAL VALLEY – LONG, SHALLOW RIFFLES WITH NO WOOD AND COARSE SEDIMENT.

6.4 Upper Transport Reach (River Mile 3.5 to 4.2)

The Upper Transport Reach is about 0.7 miles long with a valley and thalweg slope of about 0.7%. (FIGURE 30). Mainstem sinuosity is 1.0 and bankfull width ranges from 101-114 feet. Only two pools exists for a total pool area (percent of thalweg length) of about 10% and LWM density is about 20 pieces per mile at least 12 inches in diameter and 25 feet long and about 7 pieces per mile over 24 inches in diameter and 50 feet long. Sediment is dominated by cobbles (D50 = 180-256mm). Additional reach parameters are shown in TABLE 1.

Historically, this was likely more of a transport reach due to the narrow valley and relatively high terrace on river right. The flow is concentrated in a single channel and fortified with riprap (approx. 1.5 acres), and without any wood or sediment input for energy dissipation, substantial incision has occurred. According to our longitudinal profile analysis, the channel could be incised about 5-18 feet (FIGURE 31). This reach functions largely as a transport reach, with minimal opportunity for sediment storage.

FIGURE 30. EXISTING CONDITIONS WITHIN THE UPPER TRANSPORT REACH.

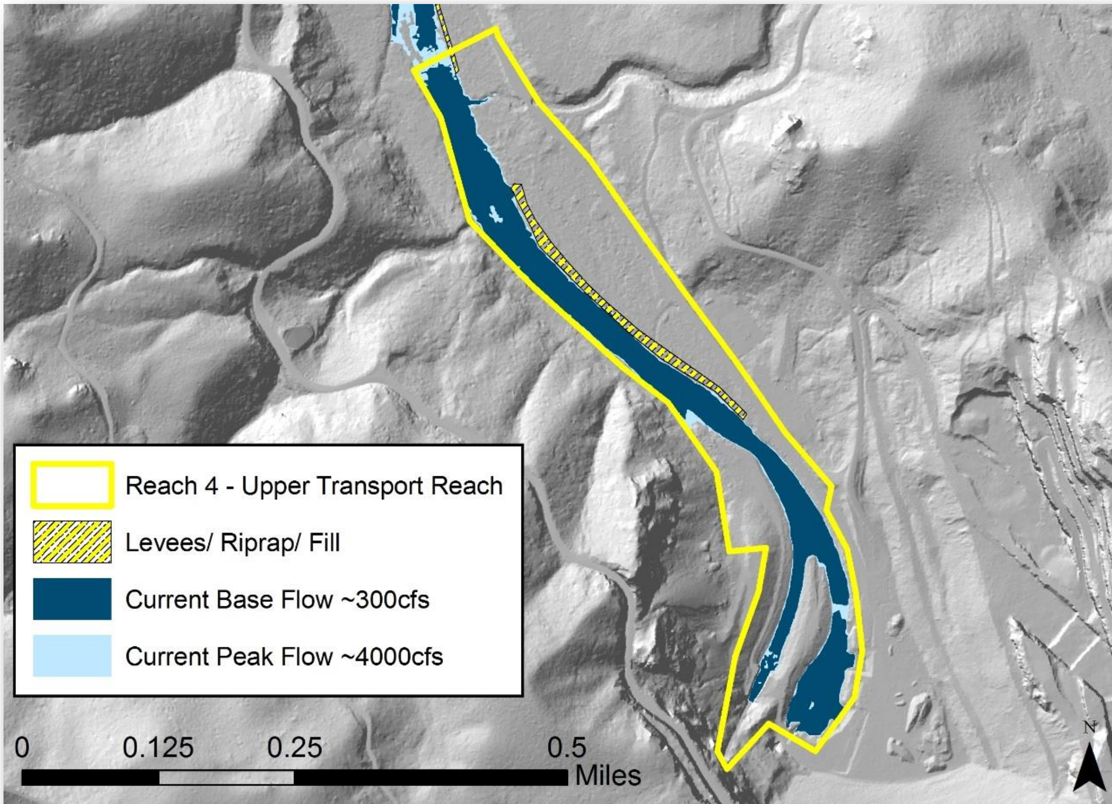
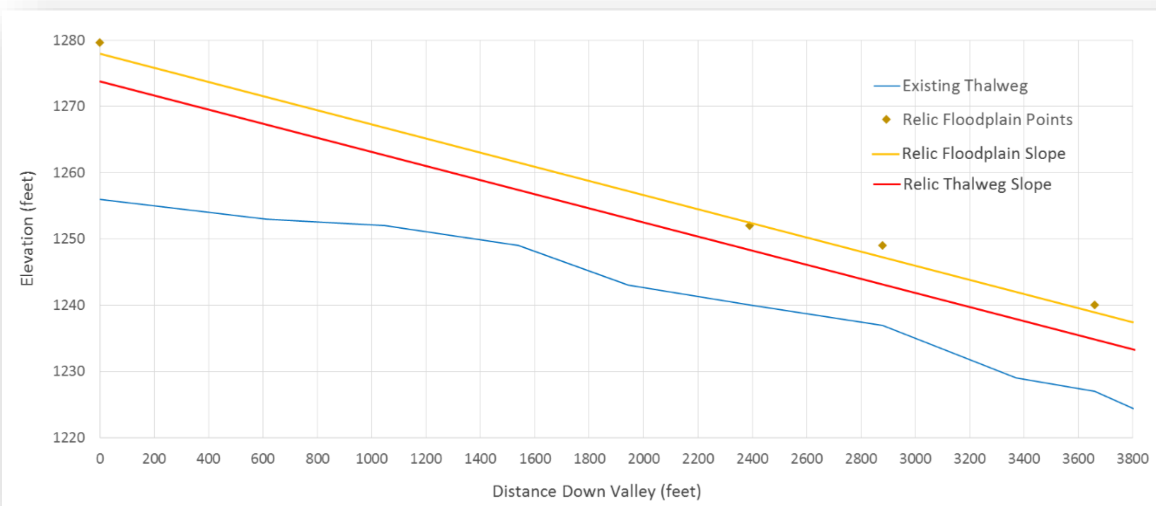


FIGURE 31. LONGITUDINAL PROFILE OF UPPER TRANSPORT REACH REVEALING APPROXIMATE LOCATION AND DEPTH OF CHANNEL INCISION [I.E. DIFFERENCE BETWEEN EXISTING (BLUE) AND RELIC (RED) THALWEG SLOPES].



6.5 Soils

There are several soil types in the Project area derived from alluvium, colluvium, glacial till and glacial outwash. Groupings of these soil types and their characteristics called land types are discussed in the WNF Soils Resource Inventory (SRI). This document, first developed in 1973, was made to provide some basic soil, bedrock and landform information with management interpretations in order to assist forestland managers in applying multiple use principles. In the Project area, most areas are in Land Type 15 and exhibit a very diverse combination of hardwood patches, mixed hardwoods and conifers, and wetland habitats. The remainder of the ground is located on relatively flat, stable, and productive side slopes of glacial and alluvial origin, primarily Land Type 16. Surface soils of both these SRI land types tend to be silty sand and gravel with moderate surface soil erosion potential and are naturally stable to very stable, characteristic of soils found on toeslopes and valley bottoms in glacially influenced terrain.

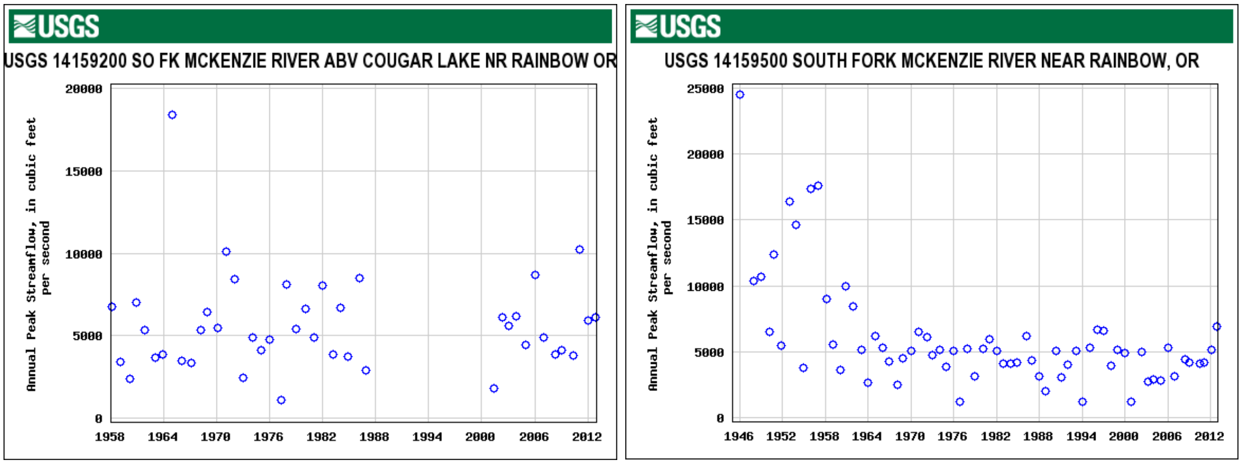
6.6 Groundwater

Water tables historically would have been high in many portions of the Project area due to the nature of alluvial environments in stream confluence areas. The frequent influx of substrate and wood, along with frequent lateral migration of multiple channels created a complex dynamic of surface and subsurface flow. Water storage and slow release through newly replenished gravel bars and back water areas would have fed side channels throughout the entire connected floodplain in the Project area, influencing the riparian vegetation complexity and the existence of wetland habitats. Stream channelization, construction of levies and berms and subsequent incision greatly lowered historic water tables, drying up once wetted floodplains and shifted vegetation towards more drought tolerant conifer species. Once connected side channels have in most cases become isolated ephemeral ponds and the extent of wetted floodplain surfaces with the potential to store and release water has been reduced by 80-90%. Revegetation planning in the project area will take into account the changes to water table that will occur immediately and into the future as floodplains are rewetted after 50 years of being disconnected.

6.7 Streamflow

The flow regime of the lower South Fork McKenzie is heavily manipulated by releases out of Cougar Dam. The dam has reduced the magnitude of flood events, increased summer and fall base flows, and changed the annual hydrograph. The flow regime below the dam can be measured at the USGS stream gauge 14159500 which has records going back to the 1940's. The current natural flows unaffected by the dam can be estimated using the USGS stream gauge 14159200 which is located above Cougar Reservoir. The 100-year flood recurrence interval went from 34,430cfs before dam construction to 8,451cfs (Risely et al. 2010). The frequency of 5 to10-year flood events decreased by 90% and floods greater than the 10-year recurrence interval (12,940cfs) have been eliminated. FIGURE 32 illustrates how peak flows have been reduced below Cougar Dam since 1963.

FIGURE 32. ANNUAL PEAK FLOW SOUTH FORK MCKENZIE RIVER ABOVE COUGAR RESERVOIR 1958 – 2012 (LEFT) AND DOWNSTREAM NEAR RAINBOW, OREGON 1946 – 2012 (RIGHT).



Peak and base flow ranges have been attenuated greatly, reducing the range and magnitude of flows, impairing the river's ability to mobilize and sort substrates. New flow paths are no longer created or abandoned to the extent they once were in response to flood events.

6.8 Sediment Regime

Currently much of the South Fork McKenzie occupies a single thread alignment confined within levees, riprap, and fill and disconnected from the floodplain with very low sinuosity. As a result, the stream is currently very efficient at transporting both water and sediment. In a few isolated areas where berms have failed or an inset floodplain is developing, the stream deposits some of its limited sediment load in gravel bars or mid-channel bars. However, the South Fork is now considered sediment limited due to Cougar Dam which captures inputs from most of the watershed. Without access to low velocity areas, nutrients are also transported efficiently downstream.

The largest gravel contributor to the lower South Fork is from the one small tributary, Cougar Creek, and from the stream eroding the glacial deposits along its banks. Due to the lack of large flood events, these erosional processes only provide limited sediment.

6.9 Vegetation

Historically, healthy riparian and wetland vegetation was well-distributed throughout the project area. With channelization and subsequent incision, groundwater levels have dropped in places. Once active floodplains were converted to dry upland terraces, and the riparian corridor is reduced to a narrow strip along the banks in many places. Relic channels with their remnant large cottonwoods are currently disconnected from the active channel. The historic upland terraces were dominated by large old growth Douglas-firs and Western red cedars. Logging and other activities during dam construction removed many acres of these old forests.

6.9.1 Native Vegetation

Native vegetation is fairly consistent across the Project area. Riparian species are primarily confined to the channel margins and the few active side channels. Alder and willows are the dominant species present in these areas. The transport reaches have a mixed conifer vegetation type but remain dominated by Douglas-fir, Western hemlock, Western red cedar, and bigleaf maple. The alluvial valleys contain more hardwoods including large decadent cottonwoods.

Riparian species with populations of Oregon ash, willow, Douglas spirea, alder, and sedges are present along the stream banks and wetted side channels. Most of the gravel bars have stabilized and are well vegetated with willow and alder.

6.9.2 Non-Native Vegetation

Spotted Knapweed (*Centaurea bierbesteinii*) and Scotch broom (*Cytisus scoparius*) are the two most prevalent invasive plants that grow in the Project area. Construction and restoration activities can increase the spread of these invasive plants.

Knapweed is dispersed through people, livestock, wildlife, vehicles, soil, and water. Knapweed populations are found through the majority of the Project area, primarily along stream corridors which accelerates dispersion. The highest concentration of knapweed is found in the Upper Alluvial Valley.

Invasive plant control has been occurring in the Project area for many years and is on-going.

6.10 Fisheries

Native fish species found in the lower South Fork include: bull trout, spring Chinook salmon, Pacific lamprey, rainbow trout, cutthroat trout, mountain whitefish, pacific brook lamprey, redside shiner, speckled dace, longnose dace, largescale sucker, Paiute sculpin, shorthead sculpin, and reticulate sculpin. Non-native species, such as brook trout and largemouth bass, are present in the project area, but are found in relatively low abundance.

The South Fork is designated as Critical Habitat for both bull trout and spring Chinook salmon. Bull trout do not spawn in the lower South Fork, but it is used as rearing, foraging, overwintering, and migratory habitat for juvenile and adult bull trout. Spring Chinook salmon use the lower South Fork spawning, rearing, and migratory habitat. Spring Chinook salmon redd abundance is unknown prior to 2001, but based on estimates of 13,000 adults once occupying the South Fork, redd abundance in the alluvial valley was likely in the thousands. TABLE 2 provides data collected by ODFW on spring Chinook salmon redd abundance below Cougar Dam since 2001.

TABLE 2. SPRING CHINOOK SALMON REDD ABUNDANCE IN THE SOUTH FORK MCKENZIE RIVER BELOW COUGAR DAM.

Year	Number of Redds
2001	61
2002	108
2003	85
2004	142
2005	86
2006	85
2007	158
2008	84
2009	68
2010	51
2011	92
2012	67
2013	36
2014	60

Use of the South Fork by other species is largely unknown. Rainbow trout, mountain whitefish, cutthroat trout, sculpin, and speckled dace are the most commonly observed species by USFS staff throughout the Project area. In the 2005 Steam Inventory survey, fish density per pool ranged from about 12-24 and densities were considered low. Pacific lamprey and Pacific brook lamprey ammocoetes have been observed when sampling via electrofishing.

The presence of Cougar Dam and levees, riprap, and fill material in conjunction with the historic in-stream and riparian removal of wood has had profound effects on fish species by reducing habitat quantity and quality and by obstructing migration. A biological assessment was recently conducted by USFS staff on the existing conditions of the Cougar Creek-South Fork McKenzie River Sub-watershed. The assessment rates the functionality of various biological and habitat indicators based on the needs of ESA-Threatened bull trout and spring Chinook salmon as either *Properly Functioning*, *Functioning at Risk*, or *Not Properly Functioning*. TABLE 3 summarizes those ratings.

The biological assessment indicates that most biological and habitat indicators are either *Functioning at Risk* or *Not Properly Functioning*. This is primarily due to the loss of habitat complexity and off-channel habitat. These features play a vital role in fish and wildlife growth and survival and are particularly important for juvenile salmonids. The smaller side channels help reduce the competition for food and space, and provide refuge from larger predators which typically occupy the primary channels. Recent studies show that floodplains contain a diversity of habitats and have higher salmonid productivity than areas of continuous flow (Connolly, 2014). Bellmore et. al. (2013) found that carrying capacity estimates based on food were 251% higher for anadromous salmonids in side channels than the main channel. A review of restoration projects by Ogsten et. al. (2014) revealed that projects that enhanced off-channel habitat increased salmonid production by 27-34%.

TABLE 3. SUMMARY OF EXISTING CONDITIONS FOR BIOLOGICAL AND HABITAT INDICATORS OF THE SOUTH FORK MCKENZIE RIVER.

INDICATOR	RANKING		
	PROPERLY FUNCTIONING	FUNCTIONING AT RISK	NOT PROPERLY FUNCTIONING
BIOLOGICAL INDICATORS			
Population Size and Distribution			
Bull trout		X	
Spring Chinook salmon		X	
Growth and Survival			
Bull trout		X	
Spring Chinook salmon		X	
Life History Diversity and Isolation and Persistence and Genetic Integrity			
Bull trout		X	
Spring Chinook salmon		X	
Temperature			
Bull trout	X		
Spring Chinook salmon	X		
Spawning Sites			
Bull trout	N/A		
Spring Chinook salmon			X
Rearing Sites			
Bull trout			X
Spring Chinook salmon			X
HABITAT INDICATORS			
Suspended Sediment, Intergravel DO, Turbidity		X	
Chemical Contamination and Nutrients	X		
Physical Barriers		X	
Substrate Character and Embeddedness			X
Large Woody Debris			X
Pool Frequency and Quality			X
Off-channel Habitat			X
Refugia			X
Streambank Condition	X		
Floodplain Connectivity			X
Change in Peak/Base Flows			X
Increase in Drainage Network			X
Road Density and Location			X
Disturbance History/Regime			X
Riparian Reserves		X	
Seeps, Springs, and Groundwater Sources		X	
Migratory Habitats		X	
Food Base		X	
Hydrograph			X
Water Quality and Quantity	X		
Non-Native Species		X	

7.0 DESIGN METHODOLOGY

7.1 Constraints

There are several important constraints that have affected the development of this restoration design. They are as follows:

- Must work within altered flow and sediment regimes below Cougar Dam
- Must work with USACE to implement actions on their land
- Must reduce risk of encountering potential contaminants during implementation and have a contingency plan in case they are encountered
- Must construct and/or maintain a primary channel without channel-spanning LWM obstructions that boaters can navigate around with minimal risk
- Must protect utilities and infrastructure, including: FS Road 19 bridge and Bonneville Power Association powerlines that cross the South Fork, Road 1900-410, Delta Campground Road and campground infrastructure
- Must work around fish and wildlife seasonal restrictions

7.2 Design Principles

7.2.1 Process-Based Restoration

The design principles incorporated into this design focus on improving natural processes and functions. We employ a "process-based" approach to restoration, rather than a "form-based" approach, which has been shown to be more successful, effective, and sustainable. Form-based restoration projects typically engineer a channel that is "balanced" in pattern, profile, and dimension and aims to efficiently transport the flow and sediment of a bankfull discharge. The restoration as designed would place the stream channels and floodplains on a trajectory that will ultimately give the system an opportunity to restore hydrologic function and begin the process of recovery. The intent is to not dictate a channel pattern, profile and dimension and transport all of the bedload. Instead the intent is to restore hydrologic processes such as floodplain connectivity that will encourage deposition and habitat development. Use of a process-based approach typically produces greater channel and habitat complexity and has the advantage of allowing the stream and floodplain to adjust to future disturbances, such as wildfires and climate change.

Typically in alluvial valleys, like the ones within the Project area, sediment is not efficiently transported and instead is deposited and temporarily stored along with organics and nutrients in point bars, mid-channel bars and islands. That means multi-threaded channels develop that are not "stable" in the classic sense. Instead the floodplain and channels are able to store sediment in some areas, change course, and adjust to changes in the watershed. Rather than having a channel that processes all of the delivered water and sediment, multiple channel options are available to be used resulting in a more dynamic aquatic environment. Likewise, channel beds are converted from armored, cobble beds without spawning or macroinvertebrate habitat to mobile, gravel beds that provide high quality spawning and macroinvertebrate habitat.

In order to restore the lower South Fork, the factors that caused the system to degrade must first be identified and corrected. The root causes of degradation include: (1) the presence of Cougar Dam, (2) the presence of levees, riprap, and fill below the dam, and (3) the historic removal of riparian and in-stream wood. We can address the latter two, but dam removal is not a restoration option at this time. Therefore, we intend to restore physical, chemical, and biological processes to the extent practicable by manually supplying wood and sediment blocked by the dam and working with the USACE to release higher peak flows.

The main design principles in this restoration plan vary by geomorphic reach. In the Lower Alluvial Valley, where the impacts are not as great, channel incision is moderate, there is intact riparian forest and future LWM supply, and there are areas currently functioning well, restoration actions will include the addition of LWM throughout the channel and floodplain, augmentation of gravels and fines, removal of riprap and fill, and construction of new ponds (Appendix C, Design Maps 1 and 2). The added LWM will dissipate stream energy causing deposition of the augmented sediment and sediment generated from within the channel network, floodplain, and banks. The channel will begin to aggrade and reconnect adjacent flow paths and floodplain. Sediment will be augmented periodically to maintain the sediment supply needed to keep the floodplain connected and to continue to develop high quality fish and wildlife habitat.

In the Upper Alluvial Valley, however, conditions are much more degraded. There is significantly more levee, riprap, and fill material and the mainstem channel is incised up to 13 feet in places. Simply removing constructed features, adding LWM, and loosely augmenting sediment would not be sufficient for the stream to recover floodplain connectivity on its own. Because incision is extreme, restoring floodplain reconnection will require manual aggradation of the incised mainstem and secondary channels (Appendix C, Design Maps 3 and 4). Once the bed elevation is "reset", then we can allow natural channel development to occur. Actions in this reach will also include removal of levee, riprap, and fill material, addition of LWM and sediment, and construction of new ponds. Because one of the Project constraints was to provide a channel without channel-spanning LWM obstructions that boaters can navigate around, we will be constructing a primary channel with carefully designed and placed logjams with many opportunities for side channels to split off.

The design for the Upper Transport Reach only includes removal of riprap to allow natural channel migration and the addition of LWM to slow velocities coming into the Upper Alluvial Valley and to improve fish habitat and cover in this reach (Appendix C, Design Maps 3 and 4). It will, however, mostly remain a transport reach.

The design for the Lower Transport Reach is similar in that it too will remain a transport reach, but in order to aggrade the channel through the Upper Alluvial Valley and maintain a gradual slope, the stream bed lift must originate in the Lower Transport Reach (Appendix C, Design Maps 3 and 4). Actions in this reach include manual aggradation of the stream bed and some addition of LWM to dissipate energy.

This design emphasizes the dynamic nature of channel pattern, variability in elevations across the floodplain and multiple channels being activated at a range of flows. Promoting the development or reconnection of other channels across a portion of the alluvial valleys will help provide abundant and diverse aquatic habitat. Recent literature has shown that ecosystem biodiversity and productivity increase with channel complexity, peaking in streams featuring network channels (Cluer and Thorne 2013, Martens and Connolly 2014). Bellmore et. al. (2013) found that carrying capacity estimates based on food were 251% higher for anadromous salmonids in side channels than the main channel. A review of restoration projects by Ogsten et. al. (2014) revealed that projects that enhanced off-channel habitat increased salmonid production by 27-34%.

Providing floodplain connection elevates the groundwater table which leads to many benefits such as improved groundwater surface water interaction and the development of a diverse riparian forest. Riparian vegetation is imperative for providing shade to the stream, allochthonous nutrient inputs, LWM recruitment, and aquatic and terrestrial habitat complexity that is necessary for the success of the Project.

As designed and implemented, the Project area will continue to evolve and develop over several years as the site reacts to improved floodplain connectivity, retained sediments and nutrients, and reestablished riparian vegetation throughout the alluvial valleys. Project area evolution will include the development of meander cut-offs, new flow alignments, mid-channel bars and many other features that in the classic restoration project would be viewed as unstable problem areas. Instead these features are recognized as natural components of a functioning river system in this setting. By reconnecting the stream system to its floodplain, this Project aims to maximize the potential to provide highly productive, diverse, and abundant aquatic and terrestrial habitat.

7.2.2 Secondary Channels

Based on relic channel scars found in the field, in historic aerial photos, and in bare earth LiDAR imagery, the evidence indicates that the South Fork historically occupied multiple channels through the alluvial valleys (Figure 17). Flows distributed into multiple flow paths significantly reduces in-channel shear stresses and allows for the development of dynamic aquatic and riparian habitats. The term secondary channel is used in this restoration plan to mean the existence of multiple channels in the two alluvial valleys at a range of elevations (i.e. not all flow channels are at the same elevation in a valley cross section). Multiple secondary channels are intended to be wetted even at low flows, as the disturbed reference reach currently demonstrates, but based on past experience and the need to maintain a navigable channel, a dominant base flow channel is likely to be maintained. This dominant low flow channel is however not designed to be static and can change from one channel to another after successive high flow events.

7.3 Lessons Learned

This design was heavily influenced by three recent restoration projects on Whychus Creek located just outside of Sisters, Oregon, where similar design principles for floodplain restoration projects have been shown very successful. Design concepts included aggrading the incised stream channel and providing floodplain access by removing berms and opening up flood paths that could be accessed at various flow levels. Restoration at Camp Polk included the construction of a mainstem channel at 70 percent of bankfull cross sectional area. The area was then planted and irrigated for two years to allow riparian vegetation establishment along and around the new channel while flows remained for the short-term in the straightened alignment along the meadow's edge. In the Spring of 2012, flows were then diverted out of the straightened alignment along the meadow's edge and returned to the valley floor. Elements of these projects that were successful in meeting design objectives were utilized in the South Fork design and include:

- Sizing mainstream channels less than 70% of bankfull cross sectional area
- Manually constructing mid-channel bars and other temporary sediment storage areas within the channel network
- Dissipating high energy flows via secondary channels
- Plugging the entire old channel alignment length where it's designed to be floodplain rather than the "plug and pond" approach

Under-sizing the mainstem channel at these two projects allowed for frequent flow into other channels and onto the floodplain surface at flows less than bankfull discharge. This allowed the newly constructed channels to remain intact and encouraged alluvium sorting and storage in point bars and mid-channel bars and fine sediment deposition on the floodplain. This approach has proven to reduce in-channel shear stresses during peak flow events and allowed the channel depth to adjust in the unconsolidated/unsorted substrate without becoming entrenched. Evaluating these projects following several flood events shows that further reduction of the mainstem channel cross sectional area and development of more temporary storage areas would have distributed energy, water and sediment more evenly throughout the project and would have accelerated the recovery rate.

Similar to projects being completed on Whychus Creek, project design for the South Fork must take into account altered flow and sediment regimes. Steps are being taken to design for peak flows that are about 25% of historical, and, as discussed above, plans are being made to augment sediment at rates comparable to West Cascades sediment input given the altered peak flow. There are other examples of more stable flow and sediment regimes in the upper McKenzie River in High Cascades geology that mimic the altered regimes of the lower South Fork. The Whychus Creek examples have provided excellent examples of design process in an altered environment and this design borrows from the Deschutes Design Team expertise.

7.4 Reference Reach Evaluations

A reference reach provides a model for project planning and evaluation. It is a well-functioning reach that is in pristine condition with plant community structure and native species diversity that provides a picture of potential vegetation for the area to be restored. Pristine or undisturbed reference reaches are very rare and more commonly disturbed reference reaches have to be used for the design. Disturbed reference reaches are segments that have been disturbed or damaged, but have recovered some function and/or are evolving in a positive trend rather than continuing to degrade.

In developing this restoration design, measured and observed parameters and conditions within the disturbed reference reach of the Lower Alluvial Valley were used (see Section 4.1 and TABLE 1). Stream function and habitat characteristics that meet Project goals and objectives from the disturbed reference reach were used as a template in this restoration design.

The disturbed reference reach can be found at river mile 1.0 to 1.2 in the Lower Alluvial Valley (FIGURE 9). This reach still lacks large wood and a sediment supply, but channels are relatively dynamic and connected to the floodplain. At this location, nearly the whole valley floor is wetted at some point in the year, which is not the case in most other areas of the Project. Recent large wood inputs at the upper end of the reach have slowed stream energy causing deposition of sediment and reconnection to the floodplain on river right (FIGURE 10 AND FIGURE 11). A large logjam at the upper end is creating deep pools, habitat complexity, and cover (FIGURE 12). Spawning-sized gravels are being sorted within floodplain side channels and fish are utilizing these areas for redd construction (FIGURE 13). There are complex, braided channels through the floodplain that are wetted at base flow (FIGURE 14), providing important thermal refugia for fish and wildlife. Riparian vegetation consists of mostly native species, including sedges, willow, alder, and cottonwood (FIGURE 15).

Using the disturbed reference reach as an indicator of potential conditions and response to disturbance, the design features for the alluvial valleys includes:

- numerous off-channel habitats and refuge during a range of flows
- abundant deep pools,

- abundant large woody material and fine organic matter,
- abundant gravels and areas of fine sediment deposition,
- channel migration/avulsions,
- areas of bank erosion/undercutting, and
- mid-channel bars and vegetated islands.

In the disturbed reference reach, channel pattern, side channel function and timing of inundation, stream habitat (pools, riffles, etc) and riparian vegetation were evaluated. What is most important about these disturbed reference areas is not the exact channel dimensions or pattern, but how the area functions over time. The area is allowed to avulse and change course, add or abandon flow paths, and effectively dissipate excess energies during flood events while maintaining high quality aquatic and riparian habitats. The disturbed reference reach displays much different sediment sorting and temporary storage than other areas along the South Fork. The functionality of these areas is the attribute emulated in the Project design.

The disturbed reference reach is connected to multiple secondary channels and the floodplain at low flows, has active mid-channel bars, and very similar slope as the design slope for this Project. The bars are collecting fine sediment and riparian vegetation is well-established. This disturbed reference reach lacks adequate instream wood and as a result, habitat has not yet matured to its potential, but it is in the process of recovering and provides a template for how that can be achieved.

These reference reaches may not appear to be reference reaches on first glance to many river restoration practitioners. Unlike the classic single-thread, Rosgen “C” channel type which, in this river system would be a cobble bed, slightly entrenched channel with moderate to high width to depth ratio and moderate to high sinuosity (Rosgen 1996). These reaches have mid-channel bars, meander cut-offs and lateral migration, all features which are characteristic of “unstable” channels. These are also characteristics typical of depositional reaches and are necessary natural channel processes in this type of system. Evaluating these reaches on function rather than aesthetics, however, shows that it is providing the highest quality habitat and most effectively attenuating large flow fluctuations.

In addition to the disturbed reference reach, there are many relic channel scars that are disconnected from current channels. These relic channels, in conjunction with the bare earth LiDAR imagery, show how the South Fork occupied the floodplain prior to channel manipulations. Rather than a clearly defined, single channel alignment, there were several channels distributed across the alluvial valleys.

7.5 Peer Review

Starting in the early conceptual design phases of this Project, the design team requested peer review from expert restoration practitioners and agencies in the region.

These reviewers were briefed on design elements being considered and conducted site visits with the design team. Cari Press, hydrologist, and Paul Powers, fish biologist, from the USFS Pacific Northwest Region Restoration Assistance Team (RAT) visited the site on June 24 and 25, 2013 and provided a report with design recommendations.

A Project tour was held for key stakeholders on August 13, 2014 during the conceptual design stage. Janine Castro, fluvial geomorphologist with the USFWS and the NMFS who has reviewed and implemented many large-scale stream restoration projects, attended and provided a written review of the Project. Chris Yee, a wildlife biologist with ODFW also attended and provided written comments.

On December 12, 2015, the 50% design was presented to interested public at the McKenzie River Ranger Station. Margaret Beilharz, retired USFS hydrologist, attended and provided written recommendations.

Comments and/or reports from these reviews can be found in Appendix B. All reviewers supported the design and offered advice that the design team considered in finalizing the design. We intend to ask each of them to review this design report as well.

7.6 Alternatives Considered

There are typically a number of alternative means to restore a project area. We considered three additional options in terms of (1) how well they met goals and objectives, (2) the degree of uncertainty in predicted outcome, (3) feasibility of success in light of various constraints (i.e. permitting, logistics, material availability, schedule), (4) impacts to cultural and natural resources, (5) sustainability and maintenance, and (6) estimated cost. The alternatives considered in developing this restoration design included the factors mentioned above in addition to feedback received from peer reviewers.

7.6.1 No Action

Many people are proponents of letting rivers heal themselves after the actions that harm them have ceased. Although riparian logging and in-stream cleanout have stopped, the presence of Cougar Dam and levees, riprap, and fill will continue to impede the recovery of the lower South Fork indefinitely. Some inputs of wood and sediment will occur naturally through channel migration, tree mortality, and blow down, but the current magnitude and rate of inputs is estimated to be less than the current magnitude and rate of transport out of the South Fork. This is evidenced by the continued decline of conditions since the dam was constructed over 50 years ago. Therefore, the primary channel will likely remain channelized, incised, disconnected from the floodplain, and lacking habitat complexity.

7.6.2 Lower Alluvial Valley Only

Because conditions in the Lower Alluvial Valley aren't as degraded as the Upper Alluvial Valley and Upper and Lower Transport Reaches, we considered an alternative that excludes the upper reaches. Under this alternative, riprap and fill material would be removed, LWM would be added to meet reference conditions, and sediment (primarily fines and gravels) would be added using the cut areas as a source. It would essentially be the same design for the Lower Alluvial Valley as that presented in this report (APPENDIX C, DESIGN MAPS 1 AND 2). Continued augmentation of sediment and wood would be needed over time to maintain high quality habitat and connected floodplain. This alternative would meet the goals and objectives for 2 miles and 392 acres of the Lower Alluvial Valley, but would not meet objectives for the upper 2.2 miles of the South Fork and associated 148 acres of floodplain. Therefore, the benefits to floodplain function and target species would be much less.

Because this is a similar project type to what we have been doing on the MRRD for a decade, the outcomes would be very predictable. The restoration techniques used to implement this project are very common, making permitting, logistics, and scheduling relatively simple. The project could be designed to leave an unobstructed path for boaters. There would be no major channel reconstruction and ground disturbance, so impacts to cultural and natural resources would be far outweighed by the benefits.

The cost of this alternative depends on the methods of implementation. The Project was designed to include helicopter placement of LWM in the Lower Alluvial Valley due to limited access, which will increase the costs. Since the sediment source is found on-site and would not require haul, at least for initial implementation, costs for sediment augmentation would be minimal. An excavator would be used to construct the mainstem logjams and push riprap and fill into the channel.

Because this alternative only restores part of the Project area, the design team feels that it significantly discounts the restoration potential and ecological benefits of the full Project area. Because the lower South Fork is such an important, unique area within the McKenzie River sub-basin, the extra investment in the upper Project area will be well worth it.

7.6.3 Passive Restoration of Upper Alluvial Valley

This alternative would attempt to passively restore floodplain connectivity over time by adding LWM to meet reference conditions and loosely augmenting sediment instead of manually aggrading the incised channel and reconstructing a channel network in the Upper Alluvial Valley. It would also include removal of levees, riprap, and fill material and all actions proposed for the Lower Alluvial Valley. The levee and fill material would be the source of sediment for augmentation. By adding LWM and loose sediment to the incised channel in the Upper Alluvial Valley, there would be some energy dissipation and storage of sediment thereby aggrading the stream bed. The depth of aggradation, however, would be minimal because the channel would still be straight and confined with high shear stresses, transporting most of the augmented sediment downstream. There would be some increase in off-channel habitat and floodplain inundation, but it would be much less than aggrading the channel manually and therefore would not have the same ecological benefits. It would only partially meet the Project goals and objectives.

The uncertainty of this alternative would be fairly high for the Upper Alluvial Valley. We would be relying on the stability of constructed logjams to withstand the high shear stresses within the incised channel and retain the augmented sediment. The chances of those logjams blowing out are high and with them will go the augmented sediment. There would be significant cost savings by not manually aggrading the incised channel, but the risk of losing the investment does not outweigh those cost savings. It would also be very difficult to add large, stable logjams and design a navigable channel through the straight, incised reach because velocities would be high. There would be fewer potential impacts to cultural and natural resources, but the benefits would also be much lower.

Based on the above factors, the design team feels that this alternative has high potential for failure and ultimately would not meet goals and objectives.

8.0 RESTORATION DESIGN

The Lower South Fork McKenzie River Floodplain Enhancement Project design is appropriate for the valley types and maximizes the amount and quality of habitat that could be expected in broad alluvial valleys. The primary components of the design are focused on the alluvial valleys and include the removal of levees, riprap, and fill material, addition of LWM and sediment, construction of new ponds, aggrading of the incised mainstem channel (and some secondary channels) through the Lower Transport Reach and Upper Alluvial Valley, and construction of a new channel network utilizing relic channels where they still exist in the Upper Alluvial Valley (Appendix C, Design Maps 1-4). Implementation will occur along multiple channels and floodplain throughout the Lower Alluvial Valley (approx. 392 acres and 2 miles) as Phase I and along multiple channels and floodplain throughout the Lower Transport Reach, the Upper Alluvial Valley, and the Upper Transport Reach (approx. 564 acres and 2.2 miles combined) as Phase II. The proposed design can be summarized as follows:

1. **Phase I – Lower Alluvial Valley** (Appendix C, Design Maps 1 and 2)
    - Removal of riprap and fill material
    - Addition of LWM and sediment
    - Construction of new ponds
2. **Phase II – Upper Alluvial Valley, Upper and Lower Transport Reaches** (Appendix C, Design Maps 3 and 4)

- Removal of levees, riprap, and fill material and additional material needed for a sediment source
- Addition of LWM and sediment
- Construction of new ponds
- Aggrading incised channels to reconnect historic flow paths and floodplain
- Construction of a new channel network utilizing relic channels where they still exist

The Project is designed to improve the quantity and quality of habitat for spring Chinook salmon, bull trout, Pacific lamprey, and other native fish and wildlife, and to improve water quality by:

- storing more water in the floodplain and slowly releasing it throughout the year,
- making more surface water available during low flow periods,
- keeping water cooler through increased hyporheic exchange through the floodplain and through augmented sediment,
- storing fine sediment within the floodplain and slow water areas instead of delivering it downstream, and
- increasing resiliency to high flows and reducing the energy transferred to downstream reaches where infrastructure is at risk and erosion could occur.

Reconnecting the channel networks to the historic floodplains will provide the elements necessary to create habitat (i.e. riparian vegetation, downed wood, deposition). Allowing high flows to escape the channel banks will encourage fine sediment deposition on the floodplain, nutrient storage in the channel and floodplain, and gravel sorting in the pool tail-outs. Dense riparian vegetation will develop on the floodplains as a result of the increase in groundwater elevation, the deposition of fine sediment on the floodplain, and the planting of diverse riparian species. Native riparian communities will provide better long term shade and wood for instream recruitment. Vegetation and down wood on floodplains that are inundated will provide slow pockets for fish to forage and seek cover, a habitat type that is lacking in the pre-Project condition. Also, the deciduous trees and shrubs established on the floodplains and stream banks will provide an energy source in the form of leaves, for the stream invertebrates, ultimately increasing the stream productivity for rearing trout and salmon.

Low channel shear stress during high flows will promote channel bedload sorting. This process allows fines to be deposited on the floodplains, larger material in the riffles, and gravels in the pool tail-outs where spawning occurs. Gravel deposits also generate much of the invertebrate production in the stream and can increase the productivity of the system.

Providing abundant in-channel and off-channel habitat through the creation of numerous channels and the addition of wood will create complex habitats including cover, over-hanging banks, alcoves, pocket pools, and lateral scour pools that are currently lacking in the Project area.

8.1 Channel and Floodplain Design

8.1.1 Lower Alluvial Valley

Removal of Riprap and Fill Material and Sediment Augmentation

In Phase I, approximately 8 acres of riprap and fill material (10,000-20,000 cubic yards) will be removed with an excavator and added directly to the mainstem channel in the Lower Alluvial Valley (Appendix C, Design Maps 1 and 2). No major levees exist in this reach. Material may be used to fill around constructed logjams for added stability and to initiate bar/island formation.

Placement of Large Woody Material

Approximately 1,500 logs with rootwad attached (15-30 inches in diameter and 50-60 feet long) and 1,500 tree tops (40-60 feet long) will be placed in the channels and floodplain throughout the reach in large or small logjams (Appendix C, Design Maps 1 and 2) with a helicopter. There will be about 50 large logjams (20-30 pieces) in primary channels that will be constructed with an excavator in the form of either “bank jams” or “island jams” (see Appendix C, Design Typicals of Logjam Structures). Bank jams will be constructed along and embedded into the bank. Island jams will be constructed within the existing channel with the intent of causing deposition around the structure to develop bars or islands. Key pieces will be embedded into the channel bed for stability. Fill material may be used to fill around constructed logjams for added stability and to initiate bar/island formation. The helicopter will initially place the wood on existing bars in close proximity to construction sites prior to construction. A skidder will only be needed to move wood short distances. In secondary channels, some log-jams placed by helicopter will be “channel-spanning jams”. Wood will be imported from off-site locations on USFS managed lands.

Construction of New Ponds

Some ponds will be constructed simply by backwatering a flow path with the placement of LWM (Appendix C, Design Maps 1 and 2). Backwater pond locations were chosen where natural depressions would easily retain standing water. Three ponds near the eastern portion of the reach will be excavated to provide deeper water depths (6-8 feet). Once excavated to desired depth, pools will be compacted and lined with fine sediment from excavated material to help seat coarse material and reduce infiltration, but no pond lining with artificial cloth will be included. At each excavated pond, 1-2 silt/clay substrate mounds (10’ x 10’ x 2’ deep) will be constructed for western pond turtle nesting. Several pieces of LWM will be added to each pond.

Measurable Outcomes

The addition of LWM and sediment in the Lower Alluvial Valley as part of our design will encourage multiple flow paths (see pages 3 and 4 of APPENDIX C, DESIGN TYPICALS OF LOGJAM STRUCTURES) as opposed to a primary channel with a bankfull width over 150 feet. Pool area is expected to increase from 19% to at least 40% within 5 years, thereby reducing the pool spacing.

Based on floodplain inundation modeling, about 81 acres of wetted channel area during base flow (about 300 cfs) is anticipated under post-project conditions (McKean et. al. 2009), a 53% increase from pre-project conditions. During peak flow events (about 4,000 cfs), about 200 acres of floodplain inundation is expected, a 52% increase from pre-project conditions. The Project is designed to activate multiple secondary channels that are activated at a range of flows, including base flow (~300cfs) as the disturbed reference reach currently demonstrates, and will provide high quality habitat as a result of LWM and sediment augmentation.

Large woody material will be placed to meet reference conditions discussed in Section 4.4 – at least 200 pieces per mile of "key" LWM (at least 24 inches in diameter and 50 feet long with rootwad) and at least 400 pieces per mile of smaller LWM (at least 12 inches in diameter and 25 feet long) in the primary channel. In secondary channels and across the floodplain an additional 900 pieces per mile will be added.

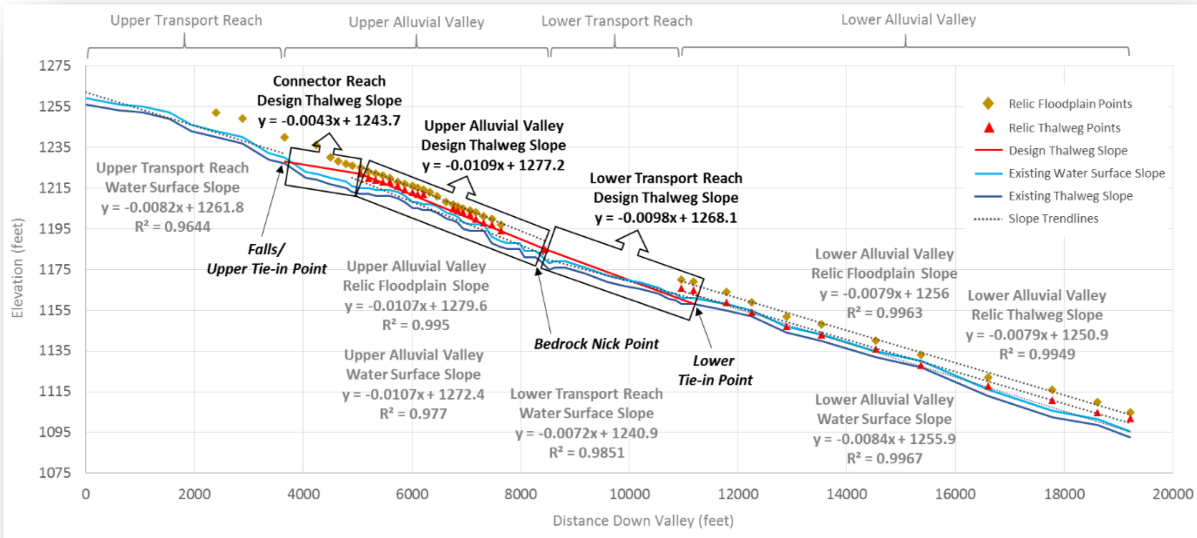
Stream power will be significantly reduced by splitting flows across multiple channels. The ability of the stream to transport a certain size particle (stream competence) will be reduced. Shear stresses have yet to be modeled for this design, but results from Whychus Creek projects indicate that there is potential to reduce shear stresses by half, from approximately 1.5 to 1.8 lbs/ft3 to approximately 0.9 lbs/ft3. We plan on completing a stream competence analysis prior to finalizing design.

TABLE **4** summarizes the measurable outcomes for this design by reach and the magnitude of change from existing conditions.

8.1.2 Upper Alluvial Valley and Upper and Lower Transport Reaches

Our longitudinal profile analysis was used to determine for each reach: (1) the relic floodplain slope that we want to reconnect to, (2) the design thalweg slope (based on relic channels and desired depth of channels below floodplain elevation), (3) the existing water surface slope (collected from LiDAR data), and (4) the estimated existing thalweg slope (based on water surface elevations and measured average depth of riffles). FIGURE 33 shows the different slopes for each reach.

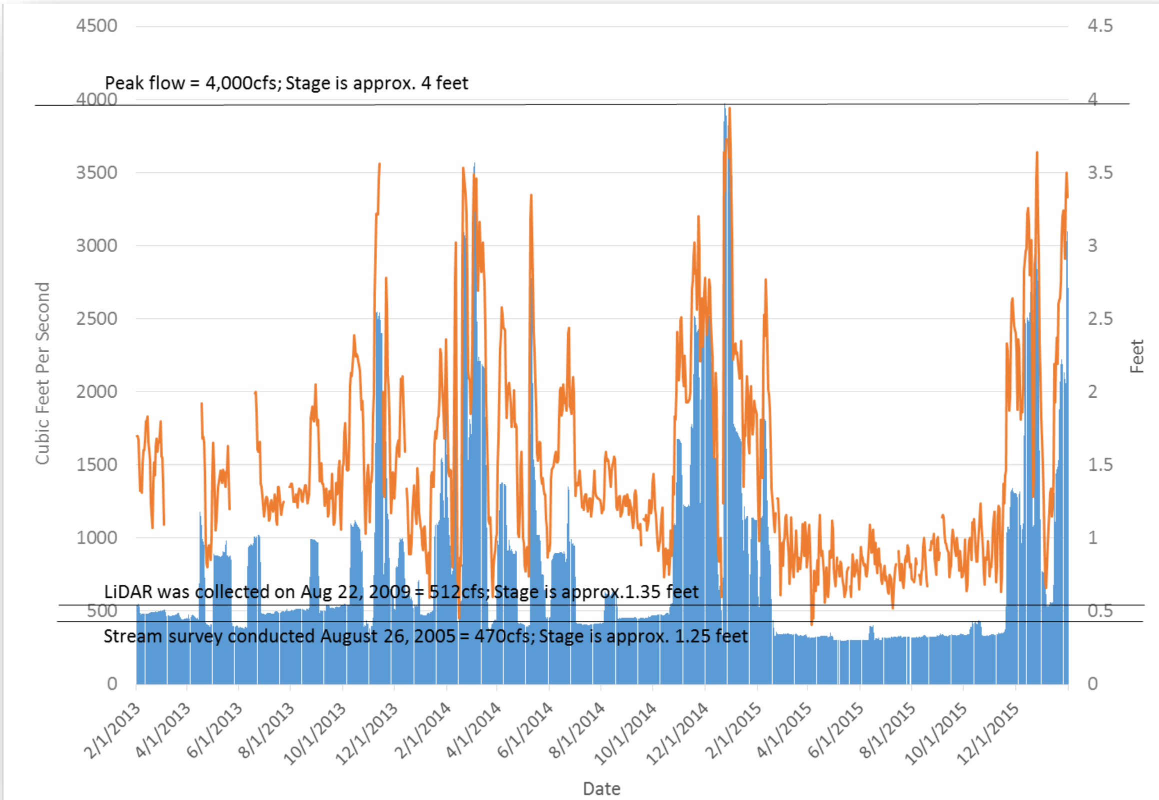
FIGURE 33. DESIGN THALWEG SLOPES SHOWN ON LONGITUDINAL PROFILE.



It would have required significantly more sediment to aggrade the channel to relic thalweg elevation through the Upper Transport Reach, so we located a small falls formed by large boulders to tie the design thalweg into at the top of the Upper Alluvial Valley. We designed a "Connector Reach" to make the design thalweg slope transition gradual. Through the Upper Alluvial Valley the design thalweg slope matches the relic thalweg slope and is about 2-3 feet below the relic floodplain slope. At the lower end of the Upper Alluvial Valley is a bedrock nick point that will help provide grade control for the aggraded channel upstream. The design thalweg through the Lower Transport Reach will gradually tie in to the existing stream bed elevation just below the Road 19 Bridge at the lower end of the Transport Reach. All slope breaks have gradual transitions that won't cause head-cutting.

The slopes developed from the longitudinal profile analysis were entered into numerous valley cross-sections throughout the Project area to determine: (1) design thalweg elevation, (2) relic floodplain elevation, (3) existing water surface elevation, and (4) estimated existing thalweg elevation at each cross-section. Predicted design base flow and peak flow water surface elevations based on the stage-discharge relationship at the USGS stream gauge (FIGURE 34) were also added to each cross-section. APPENDIX C, UPPER ALLUVIAL VALLEY EXAMPLE CROSS-SECTION shows a cross-section with aforementioned elevations. These cross-sections were used to verify relic and design elevations in the field. Once those elevations were deemed appropriate by the design team, they were then used to determine the cut and fill areas of the Project. They will also be used to layout desired elevations for implementation.

FIGURE 34. STAGE DISCHARGE RELATIONSHIP AT USGS STREAM GAUGE 14159500 ON THE SOUTH FORK MCKENZIE RIVER BELOW COUGAR DAM.



Sediment Source/Cut Areas

Phase II will begin with the removal of about 27 acres of levees, riprap, and fill material as well as some additional sediment source areas within the Upper Alluvial Valley (approx. 219,000 cubic yards total) with an excavator (APPENDIX C, DESIGN MAPS 3 AND 4). All of the cut material will be used to aggrade the incised channels, to construct new channels, and to loosely augment sediment throughout secondary relic channels. Material will be sorted on-site in order to create proper mixes for channel aggradation and construction. We expect to find a mix of sediment sizes from fines to boulders.

Areas disturbed by sediment source removal that are above expected water surface levels will be rehabilitated and replanted. A layer of finer sediment (sands and silts) approximately 6-12 inches thick, sourced from on-site, will be placed on top to prepare for planting.

Channel Aggradation

The sediment source material will be used to aggrade incised channels in order to reconnect historic flow paths and floodplain. Approximately 213,000 cubic yards of sediment is needed to aggrade the incised channels to design thalweg elevation through the Lower Transport Reach and Upper Alluvial Valley (APPENDIX C, DESIGN MAPS 3 AND 4). Sediment that will be used to aggrade incised channels will be placed in approximately one foot lifts that are watered in with fines and compressed between each lift to reduce the potential of losing flow to subsurface flow in the aggraded channel.

New Channel Construction

Once the existing mainstem channel is aggraded, a new primary channel will be constructed that will utilize relic channels where they still exist and emulate the sinuosity and pattern of well-functioning reaches in the Lower Alluvial Valley. The channel dimensions and cross-sectional area of the new primary channel will be much smaller than the existing channel because it is currently incised and because it developed under pre-dam peak flows much higher than what occurs now. Given that the desired condition is to encourage multi-thread channel development, it is important to avoid over-sizing a channel. The primary channel dimensions will be about 40% of the design bankfull area based on lessons learned from Whychus Creek projects (Section 7.3). The cross-sectional area of the existing mainstem channel is about 500-600 square feet. We want flow to generally be split between roughly 5-6 channels in a given cross-section, which results in about 100 square feet per channel. At a desired bankfull depth of 2-3 feet, each channel would have riffle widths of about 30-50 feet. If the primary channel needs to have dominant flow, then the design bankfull area would be approximately 50 feet wide by 3 feet deep – a cross-sectional area of 150 square feet. Since we will be under-sizing the channel by about 40%, the result is a bankfull area of 60 square feet, or about 30 feet wide by 2 feet deep. Following the same logic, secondary channels would have a bankfull area of about 24 square feet and dimensions of about 12 feet wide by 2 feet deep.

Constructing channels at approximately 40% cross sectional area will ensure that side channels are activated frequently and stream power is divided rather than collected. The "risk" of this technique is that some side channels may become filled with sediment and lose the capacity to convey flow at some point in the future. These channels however are to be viewed as transient, meaning that they will come and go and the temporary abandonment of any given channel fits the character of this valley form. Providing roughness in the form of LWM placements and vegetation throughout the active floodplain helps dissipate stream energy and ensures that habitat is available even when the channels shift.

Given that the design utilizes existing relic channels wherever they exist, these dimensions only apply where new channels are constructed, unless their current dimensions are greater than about 24 square feet. Rather than damaging channel banks throughout these relic channels, existing dimensions will remain and logjams will be added in select locations to reduce cross sectional area, maintain pools, and/or provide cover.

Approximately 22 pools with residual depths ranging from 2-9 feet will be constructed in the new primary channel through the Lower Transport Reach and Upper Alluvial Valley (Appendix C, Design Maps 3 and 4), increasing pool habitat to approximately 40%. Pools will also be added to newly constructed secondary channels at a similar frequency.

Large Woody Material Placement

Approximately 1,200 logs with rootwad attached (15-30 inches in diameter and 50-60 feet long) and 1,200 tree tops (40-60 feet long) will be placed in the channels and floodplain throughout the Upper Alluvial Valley and in limited portions of the transport reaches (Appendix C, Design Maps 3 and 4) to provide roughness, promote vegetation establishment, encourage complex habitat creation, and provide flow dissipation. About 45 large logjams (20-30 pieces) and over 100 small logjams (5-10 pieces) will be constructed with an excavator. In the primary channel designed to be navigable, LWM will be placed in the form of either "bank jams" or "island jams" (see Appendix C, Design Typicals of Logjam Structures). Bank jams will be constructed along and/or embedded into the bank. Island jams will be constructed within the existing channel with the intent of causing deposition around the structure to develop bars or islands. Key pieces will be embedded into the channel bed for stability. Fill material may be used to fill around constructed logjams for added stability and to initiate bar/island formation. Some wood will be placed in constructed riffles to provide structure and habitat for aquatic organisms. In secondary channels, LWM will be placed as bank jams, island jams, or channel-spanning jams. Wood will also be placed throughout the floodplain to encourage channel development, collect debris and fine sediment, and reduce floodplain velocities. A skidder will be needed to move wood from staging sites to construction sites. Wood will be imported from on and off-site locations on USFS managed lands.

Loose Sediment Augmentation (Gravels and Fines)

About 6,000 cubic yards of gravels and fines sorted from the sediment source material will be loosely distributed throughout secondary channels. Gravels will be concentrated at pool tailouts for spawning habitat and some fines will be added to the channels if they are lacking. This will ensure substrate diversity in a sediment-limited system.

Construction of New Ponds

All ponds in the Upper Alluvial Valley will be constructed simply by backwatering a flow path with the placement of LWM or not aggrading certain areas of incised channel with the intent of leaving a pond. Pond locations were chosen where natural depressions would easily retain standing water. Pond area will range from 0.2-4.0 acres and pond residual depths will range from 2-10 feet. At select ponds, 1-2 silt/clay substrate mounds (10' x 10' x 2' deep) will be constructed for western pond turtle nesting. Several pieces of LWM will be added to each pond.

Measurable Outcomes

Primary channel length remains the same in the transport reaches, but increases by over 600 feet (a 10% increase) in the Upper Alluvial Valley, decreasing channel gradient by 0.2% and increasing sinuosity from 1.1 to 1.3 (TABLE 4). Bankfull widths and width-to-depth ratios will also decrease in the Upper Alluvial Valley by up to 77%, and pool area is expected to increase from 25% to at least 40%. Pool area will increase from %15 to 20-25% in the Lower Transport Reach.

Based on floodplain inundation modeling in the Upper Alluvial Valley, about 78 acres of wetted channel area during base flow (about 300 cfs) is anticipated under post-project conditions (McKean et. al. 2009), a 136% increase from pre-project conditions. During peak flow events (about 4,000 cfs), about 112 acres of floodplain inundation is expected, a 124% increase from pre-project conditions. The Project is designed to activate multiple secondary channels at a range of flows, including base flow (~300cfs) as the disturbed reference reach currently demonstrates, and will provide high quality habitat as a result of LWM and sediment augmentation.

In the Upper Alluvial Valley, large woody material will be placed to meet reference conditions discussed in Section 4.4 – at least 200 pieces per mile of "key" LWM (at least 24 inches in diameter and 50 feet long with rootwad) and at least 400 pieces per mile of smaller LWM (at least 12 inches in diameter and 25 feet long) in the primary channel. In secondary channels and across the floodplain an additional 1,800 pieces per mile will be added. This density is much higher than in the Lower Alluvial Valley because the area of ground disturbance and un-vegetated soils will be much higher.

Stream power will be significantly reduced by splitting flows across multiple channels. The ability of the stream to transport a certain size particle (stream competence) will be reduced. Shear stresses have yet to be modeled for this design, but results from Whychus Creek projects indicate that there is potential to reduce shear stresses by half, from approximately 1.5 to 1.8 lbs/ft3 to approximately 0.9 lbs/ft3. We plan on completing a stream competence analysis prior to finalizing design.

TABLE 4 summarizes the measurable outcomes for this design by reach and the magnitude of change from existing conditions.

Table 4. Measurable outcomes from the Lower South Fork McKenzie River Floodplain Enhancement Project design.

PARAMETERS	EXISTING CONDITION	PROPOSED CONDITION	CHANGE
Lower Alluvial Valley			
Thalweg Length (miles)	2.0	2.0	0
Thalweg Water Surface Slope (%)	0.63	0.63	0
Sinuosity	1.3	1.3	0
Pool Area (% of Thalweg Length)	19	40-50	+ 111-163%
Average Pool Spacing	1,965	300-500	- 75-85%
Estimated Wetted Channel Area (acres) at Base Flow (about 300cfs)	53	81	+ 53%
Estimated Wetted Channel Area (acres) at Peak Flow (about 4000cfs)	132	200	+ 52%
Primary Channel Instream LWD Small Class (per mi)(>12" x 50'; 2005 Survey)	7	400	+ 5,614%
Primary Channel Instream LWD Medium/Large Class (per mi)(>24" x 50'; 2005 Survey)	3	200	+ 6,567%
Secondary Channel and Floodplain LWM (per mi) (>12" x 50')	Unknown	900	N/A
Shear Stress at Peak Flow (to be determined)	TBD	TBD	TBD
Lower Transport Reach			
Thalweg Length (miles)	0.5	0.5	0
Thalweg Water Surface Slope (%)	0.8	1.0	+ 25%
Sinuosity	1.0	1.0	0
Primary Channel Bankfull Average Width (feet)	127	127	0
Primary Channel Bankfull Average Depth (feet)	No Data	N/A	N/A
Primary Channel Bankfull Average Width/Depth Ratio	No Data	N/A	N/A
Pool Area (% of Thalweg Length)	15	20-25	+ 33-67%
Average Pool Spacing	2,264	500-800	+ 65-78%
Estimated Wetted Channel Area (acres) at Base Flow (about 300cfs)	10	11	+ 10%
Estimated Wetted Channel Area (acres) at Peak Flow (about 4000cfs)	11	13	+ 18%
Primary Channel Instream LWD Small Class (per mi)(>12" x 50'; 2005 Survey)	8	130	+ 1,525%
Primary Channel Instream LWD Medium/Large Class (per mi)(>24" x 50'; 2005 Survey)	0	0	0
Secondary Channel and Floodplain LWM (per mi) (>12" x 50')	N/A	N/A	N/A
Shear Stress at Peak Flow (to be determined)	TBD	TBD	TBD
Upper Alluvial Valley			
Thalweg Length (miles)	1.0	1.1	+ 10%
Thalweg Water Surface Slope (%)	0.9	0.7	- 22%
Sinuosity	1.1	1.3	+ 18%
Primary Channel Bankfull Average Width (feet)	132	30-50	- 62-77%
Primary Channel Bankfull Average Depth (feet)	4.9	2-3	- 39-59%
Primary Channel Bankfull Average Width/Depth Ratio	27	10-25	- 7-63%
Pool Area (% of Thalweg Length)	25	40-50	+ 60-100%
Average Pool Spacing	1,055	100-300	- 72-91%
Estimated Wetted Channel Area (acres) at Base Flow (about 300cfs)	33	78	+ 136%
Estimated Wetted Channel Area (acres) at Peak Flow (about 4000cfs)	50	112	+ 124%
Primary Channel Instream LWD Small Class (per mi)(>12" x 50'; 2005 Survey)	10	400	+ 3,900%

Primary Channel Instream LWD Medium/Large Class (per mi)(>24" x 50'; 2005 Survey)	3	200	+ 6,567%
Secondary Channel and Floodplain LWM (per mi) (>12" x 50')	Unknown	1800	N/A
Shear Stress at Peak Flow (to be determined)	TBD	TBD	TBD
Upper Transport Reach			
Thalweg Length (miles)	0.7	0.7	0
Water Surface Slope	0.7	0.7	0
Sinuosity	1.0	1.0	0
Primary Channel Bankfull Average Width (feet)	108	108	0
Primary Channel Bankfull Average Depth (feet)	5.2	5.2	0
Primary Channel Bankfull Average Width/Depth Ratio	21	21	0
Pool Area (% of Thalweg Length)	10	10	0
Average Pool Spacing	1,287	1,287	0
Estimated Wetted Channel Area (acres) at Base Flow (about 300cfs)	14	14	0
Estimated Wetted Channel Area (acres) at Peak Flow (about 4000cfs)	15	15	0
Primary Channel Instream LWD Small Class (per mi)(>12" x 50'; 2005 Survey)	20	100	+ 400%
Primary Channel Instream LWD Medium/Large Class (per mi)(>24" x 50'; 2005 Survey)	7	7	0
Secondary Channel and Floodplain LWM (per mi) (>12" x 50')	N/A	N/A	N/A
Shear Stress at Peak Flow (to be determined)	TBD	TBD	TBD

8.2 Materials and Quantities

TABLE 5. CUT, AGGRADE, AND SEDIMENT AUGMENTATION VOLUME ESTIMATES BY PHASE/PROJECT AREA.

PHASE	CUT (cubic yards)	AGGRADE (cubic yards)	LOOSE AUGMENTATION (cubic yards)
Phase I – Lower Project Area	10,000-20,000	N/A	10,000-20,000
Phase II – Upper Project Area	219,000	213,000	6,000

TABLE 6. LARGE WOODY MATERIAL NEEDED FOR EACH PHASE.

STRUCTURE TYPE	NUMBER OF PIECES PER STRUCTURE	NUMBER OF STRUCTURES	NUMBER OF KEY PIECES (>24" x 50' w/rootwad)	NUMBER OF SMALL PIECES (>12" x 50')
Phase I – Lower Project Area				
Large Logjam	20-30	50	400	1,100
Small Logjam	5-10	150	0	1,500
Phase II – Upper Project Area				
Large Logjam	20-30	44	200	1,120
Small Logjam	5-10	120	0	1,200
Misc. for Constructed Riffles	1	80	0	80

8.3 Logistics

8.3.1 Lower Project Area – Phase I

Preliminary logistics have been developed for Phase I. Large woody material will be imported from off-site and staged within a mile of the lower Project area. A helicopter will place the LWM as designed in secondary channels and across the floodplain. In primary channels, LWM will be placed on existing bars or banks to stage LWM in close proximity to logjam construction sites prior to construction. A skidder and excavator will then enter the channel at different access points and travel mostly within the channel corridor along cobble bars to pull riprap and fill material into the channel and to construct logjams in primary channels. A skidder will only be needed to move wood short distances.

An excavator will also be used to excavate the three easternmost ponds. Excavated material will be used on-site to create turtle nesting habitat. Excess material will be moved to the mainstem channel for in-stream augmentation.

Logjam construction will occur during base flow (approx. 300 cfs). Dewatering of logjam construction sites will be done at a site-specific scale if it is needed. Small, temporary weirs will be built from in-channel sediment to shunt water away from the immediate construction site. The weirs will be decommissioned after use. The intent is not to completely de-water a site, but to route the majority of flow around the construction site to minimize turbidity. Since the site will not technically be de-watered, fish salvage won't be needed.

Access to the primary channel will occur from Road 19, Road 1900-388, and Delta Campground Road (Appendix C, Lower Project Area Design). All disturbed areas will be rehabilitated and replanted following implementation. The in-stream work is expected to take the full in-water work period (July 1-August 15) to complete and the rehabilitation and replanting will follow. There would be considerable cost savings if Phase I is implemented in one season due to high mobilization costs of the helicopter.

8.3.2 Upper Project Area – Phase II

Logistics for Phase II are much more challenging and the design team is still working out details. In general, all work west of the existing mainstem channel – removal of levees, riprap, and fill material, aggrading incised channels, addition of LWM and sediment, and construction of new ponds and a new channel network – will occur first, working mostly in the dry (see Appendix C, Upper Project Area Logistics).

Step 2 is to aggrade the incised primary channels beginning at the lower end of the Lower Transport Reach below the Road 19 Bridge. Since there are no secondary channels through the transport reach to divert flow, flow within the channel will need to be split in order to work on one side at a time. A document in Appendix C, Aggradation

OF TRANSPORT REACH illustrates how this would be accomplished. Once the transport reach has been aggraded, pools have been constructed, and LWM has been placed, the next step is to continue aggrading the primary channels upstream on the east side of the valley (see APPENDIX C, UPPER PROJECT AREA LOGISTICS). Logistically, this will be less challenging because flow will first be diverted into the western portion of the floodplain at the upper end of the valley. Some levee material right along the mainstem channel margin will be left to keep water out of the east portion of the valley when flow is diverted. In addition to aggradation, work in this section includes removal of levees, riprap, and fill material, addition of LWM and sediment, and construction of new ponds and a new channel network. Once construction is finished, flow will be released into all channels.

Fish salvage during construction will be an important part of implementation. We will work with ODFW and volunteer groups to accomplish this. When working on aggradation of dewatered channels, personnel will be on site with nets and buckets to be able to rescue any aquatic organisms missed in initial seining prior to construction.

Heavy equipment needed for Phase II includes excavators, skidders, off-road dump trucks, industrial sieves, and dozers. Access to various parts of the upper Project area will occur from Road 19, Road 1900-410, and an existing road that accesses the western portion of the valley (APPENDIX C, UPPER PROJECT AREA DESIGN). All disturbed areas will be rehabilitated and replanted following implementation. This work is expected to take a about 9 months to complete. Work outside of streams can begin in early spring. In-stream work will occur during the in-water work period (July 1-August 15), but an extension may be needed. Multiple pieces of equipment will be employed at the same time to accomplish work within one season. The rehabilitation and replanting will follow and will last multiple years as water tables come up and begin to stabilize over time.

8.4 Revegetation Plan

Approximately 35-50 acres of ground disturbance will occur as a result of removing levees, riprap, fill, and sediment source material and for equipment access and travel. This scale of disturbance will require a robust revegetation plan that includes soil rehabilitation and invasive weed treatment. The USFS Pacific Northwest Region Restoration Services Team has formally agreed and will be funded to lead the development of a Revegetation Plan in 2016. The Revegetation Plan is a very important document that sets the foundation for all revegetation, rehabilitation, and weed treatment activities. The Plan will be used to write task orders and statements of work, to provide to contractors, and to obtain necessary permits. The Plan will be completed by October 1, 2016 and will be added to this report as an addendum.

8.5 Maintenance

Because the Project is located directly below Cougar Dam, ongoing augmentation of wood and sediment will be required to sustain floodplain function and habitat development. It was determined by the sediment budget analysis that an appropriate starting point for annual sediment augmentation following Project implementation is about 3,000 cubic yards of primarily gravels and secondarily fines. This sediment volume will be augmented one year after implementation during a peak flow event and will be subsequently monitored throughout the Project area to determine (1) if that volume is appropriate and (2) how frequently sediment should be augmented. Alluvium (about 20,000 cubic yards of gravels and fines) from construction of the fish passage facility at the base of Cougar Dam is currently stockpiled for this purpose. If augmented annually, the stockpile will last 6-7 years. It may last longer depending on the needed frequency.

Wood will also need to be maintained within an acceptable range over time. Due to the reduction in stream energy created by this project, wood is not expected to be transported out of the system. Based on experience in other LWM augmentation projects on the MRRD, periodic LWM maintenance may only be needed every 10 years or so.

8.6 Monitoring

In her peer review comments, Janine Castro writes: "There are two forms of monitoring - compliance monitoring to establish that a project is implemented as planned, and effectiveness monitoring, which evaluates how well a project meets objectives. Compliance monitoring entails inspection during implementation and as-built survey upon completion to verify that the project was conducted and built according to plan and to document deviations from the plan. Implementation monitoring is essential to verify that projects as implemented meet expectations of project owners, project funders, and regulatory agencies, and establish a critical baseline for future effectiveness monitoring. Specific protocols for effectiveness monitoring should be tied directly to project objectives such that the success of the project relative to objectives can be measured. Effectiveness monitoring helps determine if a project was successful, provides information for guiding future management actions, and helps maintain a focus on the initial project goals. The ability to measure project success will be significantly affected by the degree to which stated project objectives are measurable and have specified timeframes."

Implementation of this Project design will include both compliance monitoring (also referred to as implementation monitoring) and effectiveness monitoring. Our compliance monitoring plan has not yet been developed, but will include inspections during implementation and an as-built survey upon completion of each phase of the Project. We will use this compliance monitoring plan to make sure all design criteria developed through ESA-consultation, the NEPA process, and the permitting process are followed.

The complete effectiveness monitoring plan is included in Appendix A and include provisions for monitoring the following parameters:

- Floodplain Inundation/ Secondary Channel Habitat
- LWM Density
- Pool Area
- Dominant Substrate Size
- Chinook Redd Abundance
- Western Pond Turtle Habitat
- Waterfowl Habitat
- Amphibian Habitat
- Photopoints
- Low Elevation Aerial Photography

9.0 COST ESTIMATE

Implementation Timeline	Action	Quantity	Units	Cost/ Unit	Total Cost
FY 2016					
Feb-Dec 2016	Revegetation Plan (USFS Restoration Services Team + District specialists)	1	Plan	$18,400	$18,400
July 2016 and 2017	Pre-project Weed Treatment (2 years)	1	Lump Sum	$42,500	$42,500
Jan 2016-June 2017	Wood Source Planning - USFS Salary for NEPA (various specialists)	99	Days	$400	$39,600
Jan 2016-June 2017	USFS Salary for NEPA, design, coordination (4 staff)	30	Days	$1,400	$42,000
					$142,500
FY 2017					
May 2017-June 2021	Plant/Seed Collection and Grow-out (USFS Restoration Services Team)	1	Lump Sum	$350,000	$350,000
					$350,000
FY 2018					
March-June 2018	Upland Tree Tipping: Phase I and II	3,000	Trees	$50	$150,000
June-July 2018	Transport Upland Trees to Staging Sites (3,000 trees + 3,000 tops = ~4,500 tree equivalent)	4,500	Trees	$75	$337,500
June-July 2018	Rough Up Bucked Ends of Trees (visible mainstem trees, Wild and Scenic River)	2,500	Trees	$10	$25,000
June-July 2018	Stream Adjacent Tree Tipping	10	Trees	$1,200	$12,000
June-July 2018	Helicopter Mobilization	1	Lump Sum	$15,000	$15,000
June-July 2018	Helicopter Tree Placement (1,500 trees @ 40 trees/hour = 40 hours; 1,500 tops @100 trees/hour = 15 hours)	55	Hours	$6,000	$330,000
July-Aug 2018	Excavator Mobilization (July-Aug 2018)	2	Lump Sum	$3,000	$6,000
July-Aug 2018	Excavator Placement/ Construction of Logjams and Riprap Removal (40 structures @ 1 structure/day = 40 days	40	Days	$1,600	$64,000
July-Aug 2018	Excavator Construction of Ponds	5	Days	$1,600	$8,000
July-Aug 2018	Weed Treatment	1	Year	$10,000	$10,000
Aug-Sept 2018	Mulching/Seeding/Replanting Disturbed Areas	1	Lump Sum	$50,000	$50,000
	USFS Salary for Project Management and Implementation (6 staff)	120	Days	$2,100	$252,000
					$1,259,500
FY 2019					
March-Aug 2019	Excavator and Dump Truck Mobilization	4	Lump Sum	$6,000	$24,000
March-Aug 2019	Remove/Transport Levee Material to Sorting Sites	120	Days	$3,200	$384,000
March-Aug 2019	Industrial Sieve Mobilization	2	Lump Sum	$3,000	$6,000
March-Aug 2019	Levee Material Sorting with Industrial Sieve	20	Days	$3,000	$60,000
March-Aug 2019	Load/Transport Sediment to Staging Sites	60	Days	$3,200	$192,000
March-Aug 2019	Dozer Mobilization	2	Lump Sum	$6,000	$12,000
March-Aug 2019	Water Diversion	1	Lump Sum	$50,000	$50,000
March-Aug 2019	Aggrade Mainstem Channel with Excavator	120	Days	$1,600	$192,000

March-Aug 2019	Dozer Assistance w/ Mainstem Aggradation	60	Days	$1,600	$96,000
March-Aug 2019	Floodplain Re-grading and Channel Reconstruction	120	Days	$1,600	$192,000
March-Aug 2019	Top Soil Material (Purchased)	10,000	Cubic Yard	$10	$100,000
March-Aug 2019	Top Soil Lift on Re-graded Floodplain	20	Days	$3,200	$64,000
March-Aug 2019	Excavator Placement/Construction of Logjams (1,500 trees @ 40 trees/day = 38 days; 1,500 tops @ 80 tops/day = 19 days)	57	Days	$1,600	$91,200
	USFS Salary for Project Management and Implementation (8 Staff)	120	Days	$2,800	$336,000
					$1,799,200
FY 2020-2021					
Aug 2019-2021	Revegetation and Rehabilitation - Implementation, Monitoring, and Weed Treatment (USFS Restoration Services Team)	1	Lump Sum	$800,000	$800,000
	USFS Salary for Project Management and Implementation (4 staff)	40	Days	$1,400	$56,000
					$856,000
				TOTAL ESTIMATED PROJECT COST	**$4,407,200**

10.0 RiverRAT ANALYSIS

The RiverRAT (River Restoration Analysis Tool; Skidmore et. al. 2011) is a river project development and evaluation tool. It was developed to facilitate consistent and thorough evaluation of the potential impacts of proposed projects on river habitat. In her design review, Janine Castro indicates that the project will need to be reviewed using the RiverRAT process. That process includes answering the 16 questions that follow. To make review of this design easier, we have answered all of the questions here or referred to where they have already been addressed previously in this document (click on each Section for hyperlink reference).

1. Is the Problem Identified?

See Sections 1.1 Watershed Context and 1.2 Impacts from Land Use and Development.

2. Are Causes Identified at Appropriate Scales?

See Section 1.2 Impacts from Land Use and Development.

3. Is the Project Identified as Part of a Plan?

Yes, the project is identified in multiple plans. See Section 1.3 Restoration Need.

4. Does the Plan Consider Ecological, Geomorphic, and Socioeconomic Context?

See individual plans in 11.0 REFERENCES.

5. Do Goals and Objectives Address Problem, Causes, and Context?

See Sections 4.0 DESIRED FUTURE CONDITION and 5.0 GOALS AND OBJECTIVES.

6. Are Objectives Measureable?

See Section 5.0 GOALS AND OBJECTIVES.

7. Were Alternatives Considered?

See Section 7.6 Alternatives Considered.

8. Are Uncertainty and Risk Associated with Selected Alternative Acceptable?

Project uncertainty and risks have been discussed by the design team throughout project development, but we have not yet conducted the formal Risk Management Process, which includes 5 steps:

1. Risk Management Planning
2. Risk Identification
3. Risk Analysis
4. Risk Response Planning
5. Risk Monitoring and Control

This process will be completed prior to finalizing design.

9. Do Project Elements Collectively Support Project Objectives?

Project elements include:

- Removal of levels, riprap, and fill material
- Addition of LWM and sediment
- Construction of new ponds
- Aggrading incised channels to reconnect historic flow paths and floodplain
- Construction of a new channel network utilizing relic channels where they still exist

All project elements are necessary to obtain project objectives. The determinations are summarized as follows:

- If levees, riprap, and fill material are not removed, the stream's ability to reconnect to the historic floodplain would be very limited and ephemeral pools for amphibian breeding habitat would be limited. Therefore Objectives 1, 2, and 10 would not be met.
- If LWM wasn't added, the stream's ability to reconnect to the historic floodplain would be very limited; LWM density and pool area would remain very low; substrate particle size would remain coarse and continue to limit fish spawning habitat; and turtles and waterfowl wouldn't have adequate basking habitat. Therefore, Objectives 1-9 would not be met.
- If sediment wasn't added, the stream's ability to reconnect to the historic floodplain would be very limited; substrate particle size would remain coarse and continue to limit fish spawning habitat. Therefore, Objectives 1, 2, 6 and 7 would not be met.
- If new ponds were not constructed, turtle and waterfowl habitat would continue to be limited. Therefore, Objectives 8 and 9 would not be met.
- If incised channels were not aggraded, the stream's ability to reconnect to the historic floodplain would be very limited and ephemeral pools for amphibian breeding habitat would be limited. Therefore Objectives 1, 2, and 10 would not be met.
- If a new channel network was not constructed, there may be increased risk of currently over-sized channels capturing the majority of flow and limiting floodplain inundation and secondary channel habitat. Therefore, Objectives 1, 2, and 10 would not be met.

10. Are Design Criteria Defined for All Project Elements?

Specific design criteria are not yet fully developed. They will be defined for the final design based on outcomes of the NEPA, ESA consultation, and permitting processes.

11. Do Project Elements Work with Stream Processes to Create and Maintain Habitat?

See Sections 4.0 DESIRED FUTURE CONDITION, 7.0 DESIGN METHODOLOGY, and 8.0 RESTORATION DESIGN.

12. Is the Technical Basis of Design Sound for Each Project Element?
According to Castro, "the design process typically includes three elements of design and corresponding opportunity for design review: investigative analyses, selection of a design approach informed by investigative analyses, and development of design details for specific project elements. A 'sound' technical basis for each project element implies that an appropriate design approach (analog, empirical or analytical) has been applied, that design details are derived from and consistent with results of investigative analyses (hydrologic, geomorphic, hydraulic, sediment, and geotechnical), and that there is sufficient documentation and detail provided to demonstrate a strong rationale for proposed designs."

Throughout this design report, we have demonstrated an investigative analysis (see Sections 4.0 DESIRED FUTURE CONDITION and 6.0 EXISTING CONDITIONS), selection of a design approach that is largely informed by an analog within the same project area or within a similar geomorphic stream type (see Sections 4.0 DESIRED FUTURE CONDITION and 7.0 DESIGN METHODOLOGY), and development of design details (see Section 8.0 RESTORATION DESIGN).

Prior to our final design, we plan on conducting a sediment transport/competence analysis to confirm that our design will lead to primarily deposition and storage within the alluvial valleys and won't lead to excessive deposition in the Lower Transport Reach where infrastructure is potentially at risk. We also plan to collect more detailed data on reference reach channel dimensions.

13. Are Plans and Specs Sufficient in Scope and Detail to Execute the Project?
Since this is an 80% design report, we have not yet developed plans and specs. We will be developing plans and specs prior to final design.

14. Does Plan Address Potential Implementation Impacts and Risks?
We will be using the formal Risk Management Process, outlined in Question 8 to address potential risks of the project and potential risks during implementation. This process will be completed prior to final design.

15. Does Monitoring Plan Address Project Compliance?
Our compliance monitoring plan has not yet been developed, but will include inspections during implementation and an as-built survey upon completion of each phase of the Project. We will use this compliance monitoring plan to make sure all design criteria developed through ESA-consultation, the NEPA process, and the permitting process are followed.

16. Does Monitoring Plan Directly Measure Project Effectiveness?
See Appendix A.

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APPENDIX A. EFFECTIVENESS MONITORING PLAN

The effectiveness monitoring plan is primarily based on the project objectives, with a few extra parameters to track Project changes

Parameter	Objective	Protocol	Frequency
Floodplain Inundation/ Secondary Channel Habitat	Within the Lower Alluvial Valley, increase area of floodplain inundation and secondary channel habitat during annual peak flow (approx. 4,000 cfs) and during base flow (approx. 300 cfs) by at least 40% within 5 years of Project completion.	Model area of current floodplain inundation at mean annual peak flow approx. 4,000cfs) using River Bathymetry Toolkit and verify results in the field.	Once pre-project; Verify results pre-project, within a year of implementation, and within 5 years
	Within the Upper Alluvial Valley, increase area of floodplain inundation and secondary channel habitat during annual peak flow (approx. 4,000 cfs) and during base flow (approx. 300 cfs) by at least 100% within a year of Project completion.		
LWM Density	Within primary channels in alluvial valley reaches, increase key LWM density to at least 200 pieces per mile (at least 24 inches diameter and 50 feet long with rootwad) and small LWM density to at least 400 pieces per mile (at least 12 inches diameter and 25 feet long) upon Project completion.	Pre-project: USFS Stream Inventory Survey; Post-project: track LWM added during implementation	Once pre-project; Track LWM added during implementation; Re-survey every 5 years
	Within secondary channels and floodplain in alluvial valley reaches, increase small LWM density to at least 900 pieces per mile (at least 12 inches diameter and 25 feet long) upon Project completion.	N/A	Track LWM added during implementation
Pool Area (% Thalweg Length)	Within alluvial valley reaches, increase pool area in primary channels from 19-25% to at least 40% within 5 years of Project completion.	USFS Stream Inventory Survey	Once pre-project; Re-survey every 5 years
Dominant Substrate Size	Within alluvial valley reaches, decrease the mean particle size from cobble dominant (D50 = 128mm) to gravel dominant (D50 = 32-64mm) (in primary and large secondary channels) within 5 years of Project completion.	USFS Stream Inventory Survey	Once pre-project; Re-survey every 5 years
Chinook Redd Abundance	Increase spring Chinook salmon redd abundance by 25% within 5 years of Project completion.	ODFW Redd Survey	17 years pre-project data; Survey annually for >5 years
Western Pond Turtle Habitat	For western pond turtles, create a minimum of 5 ponds or backwater areas at least 0.25 acres in size and at least 6 feet deep that are exposed to full sun for most of the day and place several pieces of LWM in and around each pond. Create 1-2 silt/clay substrate mounds per pond (10' x 10' x 2' deep) above the 10-year floodplain in south-facing sunny areas next to ponds. Seed with native, weed-free grasses.	Track criteria during implementation; Monitor use of added habitat	Annual turtle surveys

Waterfowl Habitat	For waterfowl, create 1-2 ponds or backwater areas at least 1.5 acres in size with at least 1 small island and several pieces of floating large wood upon Project completion.	Track criteria during implementation; Monitor use of added habitat	Annual waterfowl surveys
Amphibian Habitat	Create numerous shallow, ephemeral pools on floodplain for amphibian breeding upon Project completion.	Track criteria during implementation; Monitor use of added habitat	Annual amphibian surveys
Photopoints	Establish permanent, geo-referenced photopoints at key points throughout the project area to monitor vegetation growth, channel development, large wood function, etc.	Standard photopoint protocol	Once pre-project; Re-survey annually for >5 years
Low Elevation Aerial Photography	Collect geo-referenced, low elevation aerial photographs and video of the project area prior to implementation and within 5 years of implementation to monitor vegetation growth, channel development, large wood function, etc.	Standard aerial photography protocol	Once pre-project; Re-survey every 5 years

APPENDIX B. PEER REVIEW

File Code: 2500 **Date:** June 27, 2013

Subject: June 24-25 Review of South Fork McKenzie River Project.

To: Ray Rivera, Meg Mitchell, Terry Baker, Kate Meyer

Cc: James Capurso, Brian Staab, Scott Peets, Karen Bennett, Johan Hogervorst, Nikki Swanson

On June 24 and 25, 2013, Paul Powers and Cari Press visited the South Fork McKenzie River Project near Rainbow, OR, as members of the Regional Restoration Assistance Team (RATs Team). Our team was invited to review this project by the aquatics personnel on the McKenzie River Ranger District. The RATs Team was established several years ago in Region 6 to assist Forests in all aspects of stream restoration (planning, design, implementation, and monitoring). The Team's intent is not to take the place of the skilled aquatic resources on the Forest, but to assist those resources wherever might be needed.

McKenzie River Ranger District fisheries biologists Kate Meyer and Ray Rivera began the review in the office, looking at maps, reviewing existing information and data and discussing the project areas and the Forests goals for restoration. They explained that the primary goal of the project is to restore spawning and rearing habitat for spring chinook salmon downstream of Cougar Reservoir. Following the office review we toured the project area from the Cougar Dam downstream to the McKenzie River by raft and on foot.

What follows is a brief discussion of our observations during the field review and our recommendations for rehabilitation options. This project is in the conceptual design phase.

Background

Cougar Dam was constructed by the Army Corps of Engineers as a flood control dam on the South Fork McKenzie River and was completed by 1963. The dam sits at river mile 4.5 and is 519 feet tall. Dam operations at Cougar Reservoir have significantly altered the timing and magnitude of the natural hydrograph. The high peak flows as well as the low base flow conditions have been attenuated into a more moderate and sustained flow. Average summer base flow conditions are currently in the 300 to 500 cfs range and annual peak flows top at 6,650 cfs (1996 flood event; 4,328 is the 50-year post-dam annual mean) whereas, historic base flows were between 200 and 300 cfs and annual peak flows were between 3,620 and 17,600 cfs (8,455 cfs is the 15-year annual mean, 1948-1962).

A flat terrace approximately 1.5 miles downstream of the dam on river left, now called Strube Ponds, was used for rock crushing and equipment staging during constructing of the dam. The site was part of the South Fork's historic floodplain but was cut off from the river with revetments erected during the construction of Cougar Dam. Three ponds were dug sometime between 1959 and 1964 and were connected to the South Fork through hyporheic exchange and one side channel during high flows. (Although there is no information on the original purpose for digging the ponds, there is speculation they were dug as mitigation for the habitat lost by construction of the dam.) In 1992, a habitat improvement project excavated a channel with perennial flow from the South Fork through the three ponds. While excavating a fourth pond on the north end of the site, the contractor hit ground water with an oily sheen and smell of diesel. The discovery of hydrocarbons initiated a multi-phase clean-up of the contaminants, which resulted in a fourth pond acting as a remediation pond. Effectiveness monitoring of the clean-up effort is somewhat inconclusive. Since the clean-up effort, wildlife enhancement projects have been implemented in the ponds, particularly to improve habitat for Western pond turtle and water fowl. Fish use of the ponds and side channel is limited.

Observations

We began our field tour of the project area by rafting down the 4.5 mile length. Flows during the float were at approximately 1,000 cfs. The river had a relatively high amount of power despite a relatively low discharge. We observed that as well as altering the flow regime, the dam and historic flood control practices has altered the hydrologic processes in the system. Historically it appears that the area below the dam was a large delta consisting of numerous channels that extended to the confluence with the McKenzie River (Figure B-1). The delta at Strube Ponds was highly manipulated by pushing all the flow to the river right side of the delta and confining it into one channel. The other channels were filled to create a smooth parking area and to prepare for construction of a bridge across the now single-thread river. (It is unknown whether the bridge was actually built). The area was then protected from high flows by a large rip rap berm.

Downstream of the dam efforts were made to make the stream as efficient as possible by creating a single-thread channel and clearing it of wood and other constrictions. All floodplains and side channels were disconnected from the main channel by blocking access with berms (Photos B-1, B-2 and B-3). Rip rap that lined the stream banks and/or was used to make berms appeared to be mined from the terrace at Strube Ponds and the river bed and then screened, leaving the 1-2 foot diameter boulders to be used as rip rap.

The historically dynamic, high quality spawning and rearing habitat for spring chinook had become extremely simplified by the flood control measures. In the 4.5 mile reach below the dam to the McKenzie River, there are now less than three pools and ten pieces of large wood per mile. As is typical of sediment starved reaches below dams, the channel has downcut and is disconnected from the stream by up to six feet in some places. The increased efficiency of the stream has armored the streambed and we observed approximately eight patches of spawning sized gravel in the mainstem channel, all of which appeared less than 200 square feet in area. Seventeen of the 38 active side channels, however, do have spawning sized gravel.

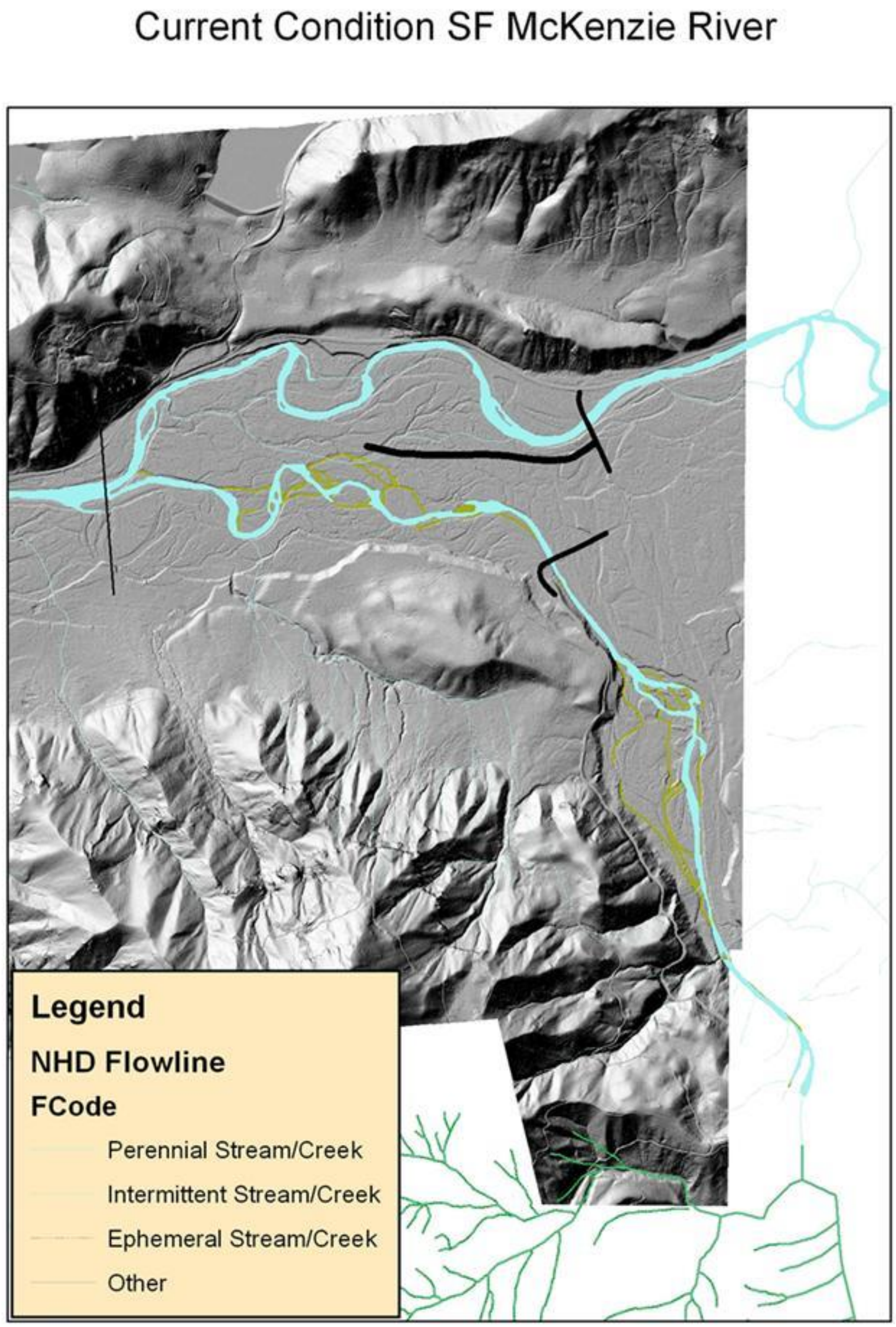


Figure B-1. LiDAR image of South Fork McKenzie and McKenzie River confluence with current flow paths.

Photos B-1 and B-2. Riprap adjacent to SF McKenzie River inhibiting floodplain interaction.

Photo B-3. Relic flow path disconnected from SF McKenzie River.


Photo B-4. Riprap blocking access to Strube Flat.


Photo B-5. Riprap lining both banks of the SF McKenzie River.

Recommendations and Discussion
During our visit we discussed options for rehabilitating the South Fork of the McKenzie River depending on the goals and objectives of the Forest and partners. The simplest and likely least expensive option would be to limit the scope of the project to developing additional off and side channel habitats, placing LWD structures to add complexity, and supplementing with spawning gravel deliveries. In this option, Strube Ponds would be left as is.

A more comprehensive project would include restoration of the hydrologic processes associated with a depositional valley type in reaches 1 and 3 in the project area (Figures B-2 and B-3). Given high terraces in reach 2 and the need to pass flows under the bridge, we would recommend leaving reach 2 as a transport reach. Activities in Option 2 includes all activities in Option 1 plus removal of all rip rap along streambanks, aggrading and realigning the mainchannel, construction of islands to shoulder water into side channels, reconnection of Strube Ponds, and construction of new side/off channels.

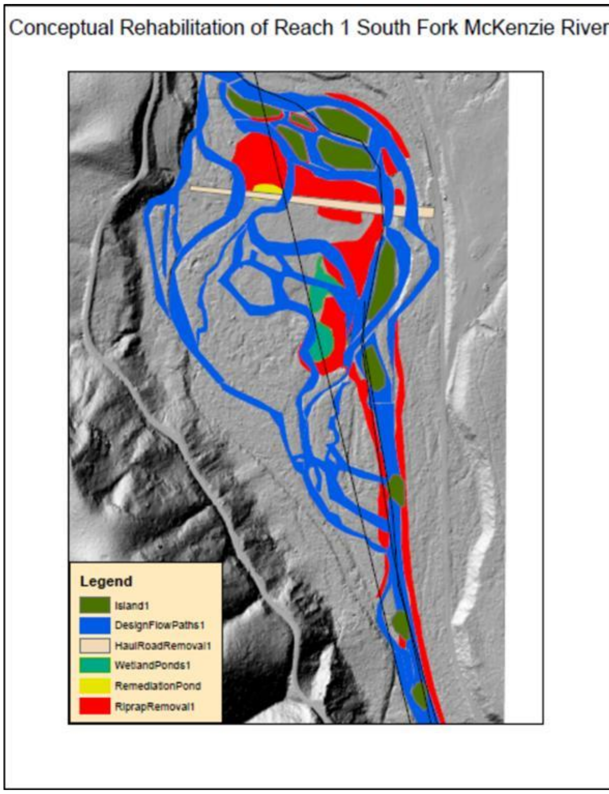
In this option all rip rap along the banks would be removed and floodplain connectivity restored. The channel elevation would tie in to the existing elevation near the start of Reach 3. Removal of the rip rap along the terrace banks would provide long-term gravel and large wood recruitment to the system as banks erode (Photo B-7). If more gravel is needed, it could be augmented with gravel supplementations. This gravel source could likely be screened from existing fill used by the Army Corps at the Strube Ponds flat.

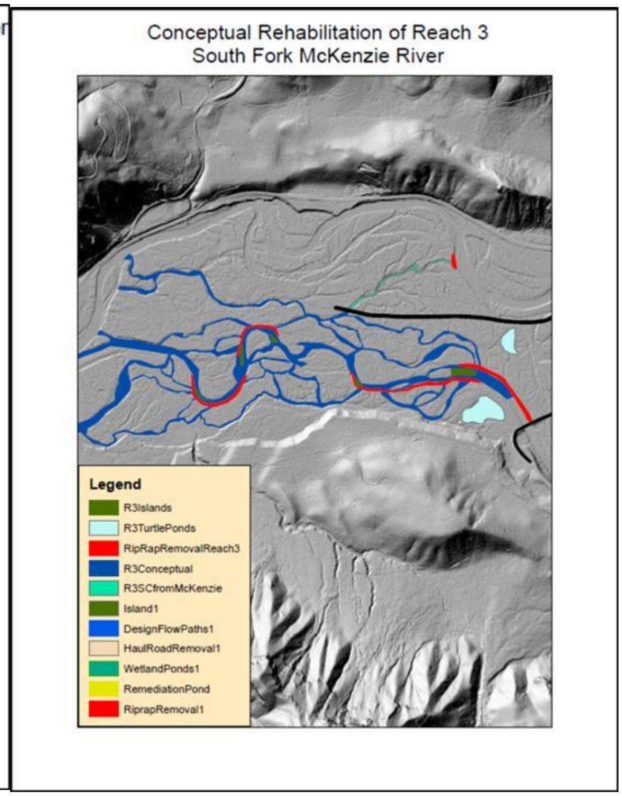
A dynamic, multi-thread channel system would be created that would dissipate flow energy and allow deposition on the floodplain. Reducing stream energy and providing a gravel source, would provide spawning habitat for spring chinook salmon. Numerous side channels across from Strube Ponds and downstream would be reconnected by simply removing berms at the entrance. Islands constructed of wood and gravel in the mainstem would help distribute flow down the side channels. Log jams and other wood would be added to all the channels to provide complexity, cover, and nutrients, recognizing that channel dominance would be dynamic (Photo B-6).

The Strube Ponds floodplain would be reconnected by removing the berm (Photo B-4) and using the material to aggrade the mainstem channel. A channel network would be created across the vast floodplain, including planting riparian vegetation and adding large wood structure. The material in the remediation pond, if toxic, would be hauled off site and ponds would be maintained or become wetlands connected to the channel network to provide aquatic and wildlife habitat.

Complete rehabilitation of this project area would be a large undertaking that would likely be implemented in multiple phases. Because of the scale of this project we recommend that the Forest solicit help and/or review from additional practitioners with valuable relevant experience such as Brian Bair with TEAMS Enterprise Team and/or Janine Castro with the U.S. Fish and Wildlife Service.

Based on the two days we spent at the project site, we recommend designing a project that would restore the hydrologic function of the system, as described in Option 2, taken into account the dam modified flow and sediment regime. Given the limited availability of large side channel networks and the importance of this type of habitat for chinook salmon, we feel Option 2 would provide the greatest biological benefit. For example, a recent restoration of the side channels near Delta Campground showed a substantial reduction in particle size and increase in chinook redd production.





Figures B-2 and B-3. Conceptual renderings of rehabilitation along the two large depositional reaches of SF McKenzie River.

Photo B-6. Reference island on McKenzie River.

Photo B-7. Alluvium that exists behind riprap layer.

McKenzie River Side Channel

In addition to the review of the SF McKenzie River project, we took a detour to look at work implemented along a side channel of the McKenzie River. The Forest Service implemented a project in two phases including tree tipping and placement of LWD via helicopter. Project activities were completed in 2012.

The project area has responded very well. We observed the accumulation of several feet of spawning gravel adjacent to each structure along with the general raising of the stream channel and reconnection with the floodplain. This is some impressive work that has had a very positive affect for spring chinook and the river.

We have greatly enjoyed reviewing this project and would be happy to help in any way that we can in the future. Thank you,

/s/ Cari Press

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Email from Janine Castro

Good afternoon,

Thanks for organizing the tour last week and for getting everyone involved early in the process. I have started my review process using RiverRAT (attached). Recognizing that this is very early in the process, I've only made it through the first 6 questions, but I thought it would be useful to provide the remaining questions that will need to be answered prior to project implementation, especially if ARBO is invoked.

Overall, I think you are headed in a good direction with the project. Recognizing that you can't completely restore the SF, opening up the floodplain to more regular inundation is probably one of the best restorative techniques available. Following are a few specific concerns/recommendations regarding the project:

- I find the use of the word "levee" confusing, because I associate levees with linear features used to prevent flooding or control channel location. Much of what we saw in the field I would describe as "fill", and hence fill removal. Not a significant issue, but perhaps that would provide future clarity, especially for potential funders.
- As I mentioned during the field visit, the designers should carefully evaluate the new hydrologic regime when determining appropriate floodplain elevations. Keep in mind that this elevation will likely be much lower than the historical floodplain -- partially due to incision, but mostly due to reduced peak flows. Because of predicted climate change impacts, I recommend erring on the side of having the floodplain a bit too low, rather than too high.
- I'm not convinced that the "incised" sections of the river are the result of classic vertical instability and subsequent disconnection from the floodplain. It is worth investigating the slope of these "floodplain" features to determine if they are actually flood terraces resulting from large flow events, debris flows, and/or log jam failures. Based on a very cursory look at the soil profile, these sediments appear to have been deposited in a single event.
- Reconnection of the floodplain should occur primary through the distributary channels and not through overbank flow. While overbank flooding does occur in natural systems, most flooding occurs from water delivered to side channels. The water is often kept separated from the main channel due to natural levees.
- Because of the altered hydrology and loss of the sediment and wood supply, serious thought should be given to long-term augmentation of sediment and wood to maintain and renew habitat. The necessary supply rates will be much lower than historically, again because of the altered hydrology.
- With the present and future regulation of flows, particularly the loss of peak flows, most habitat elements should be constructed as part of this project. It is not likely that there will be adequate stream power for the river to create new habitat over time. As was mentioned in the field, the lower SF is really a spring fed system now.

I look forward to seeing the future design options for this project. Please let me know if you have any questions or would like clarification of my comments.

Best of luck!
Janine

RiverRAT Review, August 18, 2014
Janine Castro

Project Details for Lower SF McKenzie River, Oregon
1: Is the problem identified?

Yes

Comments

08/18/2014 12:40 PM: JANINE_M_CASTRO@FWS.GOV
This review is based off of the Lower South Fork McKenzie River Enhancement Project, Core Stakeholder Field Tour Packet, August 13, 2014. "The root causes of habitat degradation are the presence of Cougar Dam and levees below the dam. They have altered the following physical and biological processes: • Flow regime and stream flow routing • Supply, transport, and retention of sediment, large wood, and nutrients • Floodplain building and flood storage • Pool or bar formation • Channel migration • Litter fall reduced due to riparian conversion to conifers • Pond formation reduced due to lack of beaver-preferred vegetation due to riparian conversion to conifers • Secondary production altered due to loss of nutrient delivery, loss of leaf litter, and lack of sediment supply/substrate diversity • Feeding/predation altered due to changes in secondary production and physical habitat (e.g. loss of side channels)."

2: Are causes identified at appropriate scales?

Yes

Comments

08/18/2014 12:40 PM: JANINE_M_CASTRO@FWS.GOV
Watershed scale problem -- dam construction and hydroregulation.

3: Is the project identified as part of a plan?

Yes

Comments

08/18/2014 12:54 PM: JANINE_M_CASTRO@FWS.GOV
"The Forest Service recently developed the Watershed Condition Framework to establish a new consistent, comparable, and credible process for improving the health of watersheds on National Forests. Watershed condition classification was completed in 2011 and priority watersheds were identified. The South Fork McKenzie River was selected as the priority watershed for the McKenzie River Ranger District based on the high potential for restoration benefits to various natural resources. The Cougar Creek subwatershed was subsequently chosen as the first priority for an action plan. In 2012, the Cougar Creek Watershed Restoration Action Plan was signed and

essential projects were identified to move the watershed condition rating from Functioning at Risk towards Functioning Properly. This project will complete Essential Projects #1 and #2 in that plan. Essential Project #3, Cougar Creek Aquatic Organism Passage, was completed in 2013, and the remaining projects #4-6 are in progress and should be completed by 2015. The South Fork is an important river for ESA-Threatened spring Chinook salmon and bull trout and habitat restoration is emphasized in the Upper Willamette River Conservation & Recovery Plan for Chinook Salmon & Steelhead (ODFW and NMFS 2011), the Bull Trout Draft Recovery Plan (USFWS 2002) and the 2014 Upper Willamette Basin Bull Trout Action Plan."

4: Does the plan consider ecological, geomorphic, and socioeconomic context?

Yes

Comments

5: Do goals and objectives address problem, causes, and context?

Yes

Comments

08/18/2014 12:45 PM: JANINE_M_CASTRO@FWS.GOV
The goal is partial restoration given the presence of Cougar Dam. "The overall goal for the project is to improve physical, chemical, and biological processes that support a healthy, resilient ecosystem and sustain habitat conditions for native species, specifically spring Chinook salmon, bull trout, Pacific lamprey, Western pond turtle, amphibians, beaver, and waterfowl. We also want to create an easily accessible NatureWatch area for the local community."

6: Are objectives measurable?

Yes

Comments

08/18/2014 12:46 PM: JANINE_M_CASTRO@FWS.GOV
"The objectives include: 1. Increase area of floodplain inundation (during events greater than the mean annual peak flow; approx. 4,262 cfs) by at least 25% upon project completion. 2. Increase area of secondary channel habitat (during events greater than the mean annual peak flow; approx. 4,262 cfs) by at least 25% upon project completion. 3. Increase large wood frequency to at least 300 pieces per mile (>12” x 25’) in the channel and floodplain upon project completion. 4. Increase pool area (in mainstem and side channels) by at least 25% within 5 years of project completion. 5. Decrease the mean particle size to 50-100mm (in mainstem and side channels) within 5 years of project completion. 6. Increase spring Chinook salmon redd abundance by 25% within 5 years of project completion. 7. For western pond turtles, create a minimum of 5 ponds or backwater areas at least 0.25 acres in size and at least 6 feet deep that are exposed to full sun for most of the day upon project completion. 8. For turtle nesting, create 1-2 silt/clay substrate

mounds per pond (10’ x 10’ x 2’ deep) above the 10-year floodplain in south-facing sunny areas next to ponds upon project completion. Seed with native, weed-free grasses. 9. For turtle basking and dispersal, place several pieces of large wood in and around each pond upon project completion. 10. For waterfowl, create 1-2 ponds or backwater areas at least 1.5 acres in size with at least 1 small island and several pieces of floating large wood upon project completion. 11. Create numerous shallow, ephemeral pools on floodplain for amphibian breeding upon project completion. 12. On floodplains and riparian areas create or maintain at least: 10% open wetlands with grasses, sedges, and rushes; 15% shrub-dominant riparian area; 15% hardwood-dominant riparian area; and 30% coniferous forest upon project completion. 13. Create a trail system with safe water crossings and boardwalks for access as a NatureWatch site within 5 years of levee removal."

7: Were alternatives considered?

Question 7: There are typically a number of alternative means to meet stated goals and objectives. No project should proceed without formal consideration of alternatives, and a "no action" alternative should always be considered. Any proposed alternative that includes instream actions that may impact the resource, aquatic species, or natural processes should be compared against alternatives that avoid these potential impacts, either through a no-action alternative or other management actions that minimize alteration of the stream. Alternatives analysis typically requires significant levels of investigative analysis (i.e. geomorphic, hydrologic, hydraulic, sediment transport, geotechnical), sufficient to develop concept-level designs for all alternatives. As such, the alternatives evaluation process is effectively a large step forward in the design process. An alternatives evaluation involves basic analysis of: * Goals/objectives - how well it satisfies goals and objectives * Uncertainty - the degree of uncertainty in predicted outcome * Feasibility - permitting, constraints, schedule * Impacts - cumulative, short- and long-term * Sustainability and maintenance - probable or required ongoing action * Cost

Comments

8: Are uncertainty and risk associated with selected alternative acceptable?

Question 8: Uncertainties and risks are inherent to any river project action or change in management. Acknowledgment of uncertainty and associated risk is critical to project development and design, and should be considered in project review. Uncertainty refers to a lack of sureness about some project element, and can be attributed to either natural variability or knowledge uncertainty. Uncertainty associated with natural variability is inherent to the river system, and cannot be reduced. Knowledge uncertainty is a property of the analysis, the information available, or the analytical tools. Risk, defined as the probability of an impact occurring and the extent of harm it will cause, can often be reduced by reducing uncertainty. A risk analysis considers potential impacts of discrete project elements, then reconstructs the project and considers the whole. In reviewing projects, there are a number of different types of risk that should be considered, including: * risk to listed species (take), * risk to project owners (cost, liability), * risk to ecosystem (environmental degradation), * social risk (perception associated with project failing to meet objectives), and * institutional risk (creating or perpetuating risk averse management).

Comments

9: Do project elements collectively support project objectives?

Question 9: Project elements are distinct project components that in concert constitute a complete reach-scale reconfiguration or stabilization design. In project review, it is often useful to deconstruct a project into its constituent elements to evaluate whether each of them is necessary, appropriate, and contributes to project goals and objectives. For example, a proposed restoration project may include channel reconstruction. Discrete project elements may include planform reconfiguration, large wood or other habitat structures, streambank stabilization, or floodplain modification. These project elements can be reviewed individually to determine if they contribute to the objectives, and collectively to determine if they support the stated goal. Well-intentioned designs may include project elements that appear attractive, but when evaluated relative to objectives, serve little or no purpose, or may present more risk than potential value.

Comments

10: Are design criteria defined for all project elements?

Question 10: Design criteria are specific, measurable attributes of project components developed to clarify the intent of project elements and define expectations of their performance relative to objectives. Design criteria provide a vital link between project objectives and design by providing specific target conditions to achieve through design and associated implementation. Most design criteria for river projects should be clearly linked to a specific design discharge, which may vary among project elements. Design criteria are a common element of design for many practitioners trained in engineering, but are not commonly applied in river restoration or stabilization applications. Design criteria may be either prescriptive criteria or performance criteria. Prescriptive describe specific required attributes of the project element; performance describe specific performance attributes of the design element. While prescriptive criteria may be easier to develop designs for and to measure success, they do not necessarily result in project elements that meet objectives. Performance criteria are more suited to direct correlation to project objectives, but may be more difficult to establish measurable design attributes for.

Comments

11: Do project elements work with stream processes to create and maintain habitat?

Question 11: In undisturbed river systems, physical habitat is created and maintained by scour, erosion, and deposition of bed materials, and the recruitment and accumulation of large wood and other natural materials. Though inputs are variable over time, the average volume, character and quality of habitat remains relatively constant in unaltered systems. Project elements that act in concert to either restore or sustain these inputs and processes will support systems that create and maintain habitat over time. Conversely, project elements that constrain processes, inputs, or the ability of the channel to adjust may result in systems that require maintenance or are otherwise unsustainable. A simple example of this is the use of large angular and immobile rock to construct project elements in an alluvial system. By design, such rock constrains processes and inputs. Though this may not be the intent of the design, there is a strong temptation to design project elements to be stable and permanent rather than deformable and temporary. While the latter conditions promote natural processes that create and maintain habitat, the former are more commonly applied to compensate for the risk of 'failure' of discrete project elements, and consequently may contradict project objectives that include restoration, sustainability, and natural processes.

Comments

12: Is the technical basis of design sound for each project element?

Question 12: The design process typically includes three elements of design and corresponding opportunity for design review: investigative analyses, selection of a design approach informed by investigative analyses, and development of design details for specific project elements. A 'sound' technical basis for each project element implies that an appropriate design approach (analog, empirical or analytical) has been applied, that design details are derived from and consistent with results of investigative analyses (hydrologic, geomorphic, hydraulic, sediment, and geotechnical), and that there is sufficient documentation and detail provided to demonstrate a strong rationale for proposed designs. The depth of scrutiny appropriate for review of specific projects may be evaluated using the 'Project Screening Risk Matrix'. There is often a strong correlation between the integrity of design documentation and the design itself. Thorough design documentation not only provides information necessary for review, including a list of assumptions for each design analysis, but usually also provides justification for proposed designs. Thus, the ease with which a reviewer can access relevant information and answer review questions from project information provided may be a useful screening criterion in and of itself.

13: Are plans and specs sufficient in scope and detail to execute the project?

Question 13: Plans and specifications are the blueprints for a project. They refer to the architectural and engineering drawings of proposed project elements (plans) and descriptions of specific materials and techniques (specifications) that direct the implementation of the project. The level of detail provided may range from conceptual to detailed, where conceptual plans may assume considerable construction oversight will be required to manage fit-in-field decisions and adaptations, and detailed plans may be sufficient for a contractor to develop a contract price for implementation and require minimal oversight. Concept level final design is often implemented in a 'design build' approach and may realize significant cost savings in design, but makes it challenging to evaluate risk in advance. Ultimately, consideration of risk among various interests is necessary to evaluate the implications of varying levels of detail in plans and specifications.

14: Does plan address potential implementation impacts and risks?

Question 14: Any actions within the stream channel, its banks, or floodplain will necessarily impact the resource or the species that depend on that resource. These impacts may be temporary and limited to the construction period, or may be long-term. The known impacts and potential risks should be clearly identified in a project proposal and plan, and measures such as construction BMPs put in place to minimize impacts and reduce risks associated with implementation. The likelihood of anticipated or unexpected implementation impacts can be minimized/mitigated by thoughtful pre-project planning including detailed construction sequencing, analysis of probabilities of storm flows and resultant river stage during construction window, sediment and erosion control practices, construction BMPs, and contingency planning. A lack of detail in implementation plans may be viewed as a red flag for unexpected or unintended impacts to listed species. Monitoring plans should include measures for evaluating potential impacts.

15: Does monitoring plan address project compliance?

Question 15: There are two forms of monitoring - compliance monitoring to establish that a project is implemented as planned, and effectiveness monitoring, which evaluates how well a project meets objectives. Compliance monitoring entails inspection during implementation and as-built survey upon completion to verify that the project was conducted and built according to plan and to document deviations from the plan. Implementation monitoring is essential to verify that projects as implemented meet expectations of project owners, project funders, and regulatory agencies, and establish a critical baseline for future effectiveness monitoring.

16: Does monitoring plan directly measure project effectiveness?

Question 16: There are two forms of monitoring - compliance monitoring to establish a project is implemented as planned, and effectiveness monitoring, which evaluates how well a project meets objectives. Specific protocols for effectiveness monitoring should be tied directly to project objectives such that the success of the project relative to objectives can be measured. Effectiveness monitoring helps determine if a project was successful, provides information for guiding future management actions, and helps maintain a focus on the initial project goals. The ability to measure project success will be significantly affected by the degree to which stated project objectives are measurable and have specified timeframes.

Oregon
John A. Kitzhaber, MD, Governor

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September 9, 2014

Jared Weybright
McKenzie River Watershed Council
POB 70166
Springfield, OR 97475

Kate Meyer
McKenzie River Ranger District – Willamette NF
57600 McKenzie Hwy
McKenzie Bridge, OR 97413

RE: Lower South Fork McKenzie River Enhancement Project

Thank you for the opportunity to provide comments regarding the Lower South Fork McKenzie River Enhancement Project. This project proposes to restore several natural processes and features to the river system that were lost following the construction of Cougar Dam.

I have provided some comments specific to the project objectives listed in the handouts you included for the site visit:

Objective 3 – Log jams in slower moving areas of the river could also provide substantial benefits as basking and cover structures for Western pond turtles.

Objective 7 –Fluvial-based turtles typically spend more time on land (e.g., moving between seasonal resources or breeding sites, estivating, hibernating, etc.) than their lacustrine or palustrine conspecifics. Depth is likely less important than providing forage and cover for turtles. For example, the large pond we visited generally lacked forage and cover. A few isolated areas occurred adjacent to the shoreline, but overall this pond should be considered as poor habitat for turtles. Focusing on forage and cover features should benefit amphibians, waterfowl, and insectivorous birds that utilize pond or backwater areas as well.

Objective 8 – Nesting mounds may not be as beneficial as sculpting the bank to provide more choices for nesting turtles. Additionally, the smaller sized mounds can lead to increased nest depredation rates. Turtles will nest in any gently sloped areas with adequate solarization, regardless of aspect. South-facing slopes are not necessarily better than other areas that provide quality nest site characteristics. Be sure to include appropriate forbs in the seed mixture and not to seed with grasses that have aggressive growth patterns. Planting forbs a year prior to planting grasses may facilitate better forb establishment. Or adding forbs to a combined mixture can help retard grass growth and provide a more open-spaced plant community preferred by nesting turtles.

Objective 9 – Large wood placement will benefit adult turtles. However, hatchlings are predominately thought to bask while resting on aquatic vegetation at the water's surface. Consider placing tree tops or branch structures in shallower emergent areas that hatchlings would use. These areas should be spatially situated near potential nesting habitat. Smaller wood features may have importance to hatchling turtles in providing protection from predators. For example, herons depredate hatchling turtles in these shallow, emergent areas by stalking and sighting. These structures can provide hiding cover for hatchlings and obstructions that make this stalk and sight technique ineffective.

Objective 12 – Consider implementing additional browse cut back in some areas to stimulate regrowth. This action would benefit deer and elk foraging habitat.

Additional comment – We also discussed the non-native invasive plant seedbank that likely exists within the surface layer of the levee material. It may be prudent to scrape the levee surface and leave that material on land instead of using it for river channel reconstruction.

Thanks again for soliciting our input on your project. Please do not hesitate to contact me at 541.726.3515 x27 or Christopher.g.yee@state.or.us should you have any questions or comments.

Respectfully,

Christopher G. Yee

Date: 12/14/2015

To: Kate Meyer

Subject: Lower South Fork McKenzie River Floodplain Enhancement

Thank you for the opportunity to comment on the Lower South Fork McKenzie River Floodplain Enhancement Project. And thank you for the high quality public presentation about the project given by Ray Rivera and Kate Meyer at the McKenzie Ranger Station this morning.

My comments are based on 1) my technical understanding of the issues, which I developed during my 25 years as a Hydrologist for the US Forest Service, with the last 10 of those focusing on instream flow issues in hydropower projects; and 2) my observations as a now-retired, long-term resident and property owner two miles from the project area.

Purpose and Objectives: I strongly support the purpose of the project, as stated in your scoping letter. The geomorphic characteristics of the proposed project area is unique in the McKenzie River drainage, and as you have pointed out, historically provided a large quantity of high-quality habitat for aquatic and related wildlife species. The effects of Cougar Dam (through reduction of flows, large wood, and gravels) on the habitats of the South Fork and mainstem McKenzie have been severe and long-lasting, and they are not easy to counter. This is an ambitious and much-needed project.

Tyson Cross's introduction this morning emphasized "balancing" the needs of access and habitat restoration. I would add to this, the balance should be considered in terms of the McKenzie River as a whole, not just the South Fork area. There are many miles of the McKenzie River where aquatic habitat is altered to enable recreational boat passage. Most of those areas do not have the extremely high floodplain habitat potential found in the South Fork project area. I feel strongly that habitat restoration needs should take priority over providing for boat passage by minimizing habitat structure in some channels. Habitat enhancement in this area will clearly contribute to population resiliency of the species throughout the upper McKenzie River drainage.

Location: Has there been an inventory of all side-channels in the area to select which channels to work in? Some floodplain mapping of the McKenzie River have recently been completed and may help verify the project's assumptions about extent and frequency of floodplain inundation in light of the altered flow regime.

Flows: The quantity, timing , duration, and rate of change of water flowing through the area is one of the critical habitat characteristics. It will be important to know how much flexibility the Army Corps has to fine-tune the amount and timing of releases for the specific goals of this project. Specific flows may be needed a) during removal of the levees and fill; b) during placement of gravel and wood, c) to c) to distribute the gravels and to a lesser extent, the wood, and d) to be deep enough to provide habitat objectives. A good analysis description of the function of various flows, and analysis of hydrologic conditions is available in Development of an Environmental Flow Framework for the McKenzie River Basin, Oregon.

As mentioned in your presentation, the reduction in the peak flows below the dam result in daily flows reaching fewer side channels. One of the largest challenges in managing regulated reaches is whether to and how to "downsize" the entire hydrologic and physical conditions of the reach. The numbers on page 23 of the report listed above show this challenge. It shows that the 2 year recurrence event is now 4262 cfs, (it used to be 6392 cfs), while the 100 year is 8451 cfs - is about 100% greater. In the same reach without regulation the same recurrence flows were 9242 cfs, and 34430 cfs respectively, or 370% greater. Thus, the 10 year event used to be 100% greater than the 2 year event, and now it is only 50% greater. This means, that under current Army Corp release practices, the relative expansion of the flows will occur only once in 100 years, rather than once every 10 years. Flows in the range of 2 to 10 year frequency are often most important for moving and sorting gravels within the active channel, so it might be good to work with the Corps to get a release of several thousand cfs greater than the 2 year level more frequently.

The rate of decrease in flows is also important. While working on hydropower flow regimes, I also noticed that when gravels are mobile, if flows are reduced rapidly the gravels may be more likely to be left "high and dry" at the upper edge of the channel; whereas when flows are tapered off the gravels are more likely to be moved into the lower part of the channel which is most likely to remain wetted during low flows.

Gravel Placement: There are several options for how to place gravel in the channel. It could be placed in the channel at the head of each project area (Phase I and II), and be transported to the reach below (after Large wood is placed) by controlled flow releases. The second option would be to place it with large equipment in specific areas. A combination of both approaches is also possible.

Gravel Source: A long-term source of gravel to consider is the South Fork at the head of the reservoir, at the upper limit of the draw-down zone. This would be near the Slide Creek bridge. The reservoir is usually drawn down during the high flows that move gravel, so a sediment collection basin could be constructed in the channel at an elevation in the upper part of the active channel, but in the draw-down zone. Trucking sediment from this source would retain the geochemical characteristics of the watershed, and would probably be much less expensive than other sources.

While sediment transport analyses can be complex in braided channels, some means of testing the relationship between gravel sizes and flow levels is needed. For example, in the Carmen-Smith relicensing, EWEB used field verification by marking rocks with paint at various cross sections, and monitoring what flow levels transported the marked rocks.

Wood placement: at the meeting it was said that all pieces of wood would have rootwads. I question the need for all of the pieces to need rootwads, since many pieces without rootwads can jam into the larger, heavier pieces. And I see many piles of material in nearby barely economical commercial thinning units.

Recreation Use: Although not an objective of this project, we know that how and where equipment is used during this project can influence dispersed recreation use by creating temporary roads that are easily converted into trails. From a socio-economic aspect, the South Fork is very accessible and has a high potential for trail-based recreation use. The Delta-Old Growth trail is very popular with local residents because it is low-elevation, low-gradient, and relatively short. These types of trails are increasingly important to the tourism-based economy of the area. We have seen the McKenzie River Trail skyrocket in popularity primarily by trail-bikes, resulting in some signs of overuse. A 4- mile trail in this location could spread the expected, and wanted recreational uses. The area could also use more handicapped accessible trails. Such a trail need to necessarily parallel close to the river, but far enough that side-trails could provide bank access for wild-life viewing, bank fishing, swimming, and other activities.

Thanks for the opportunity to comment, and I look forward to reading more about the project.

Margaret Beilharz

ph 541 514 7433

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APPENDIX C. DESIGN MAPS AND FIGURES

- Figure C-1: Design Map 1 – Lower Project Area Design
- Figure C-2: Design Map 2 – Lower Alluvial Valley Design Detail
- Figure C-3: Design Map 3 – Upper Project Area Design
- Figure C-4: Design Map 4 – Upper Alluvial Valley Design Detail
- Figure C-5: Design Map 5 – Upper Project Area Logistics
- Figure C-6: Aggradation of Transport Reach Example Cross-Section
- Figure C-7: Upper Alluvial Valley Example Cross-Section
- Figure C-8: Design Typicals of Logjam Structures

Figure C-1: Design Map 1 – Lower Project Area Design

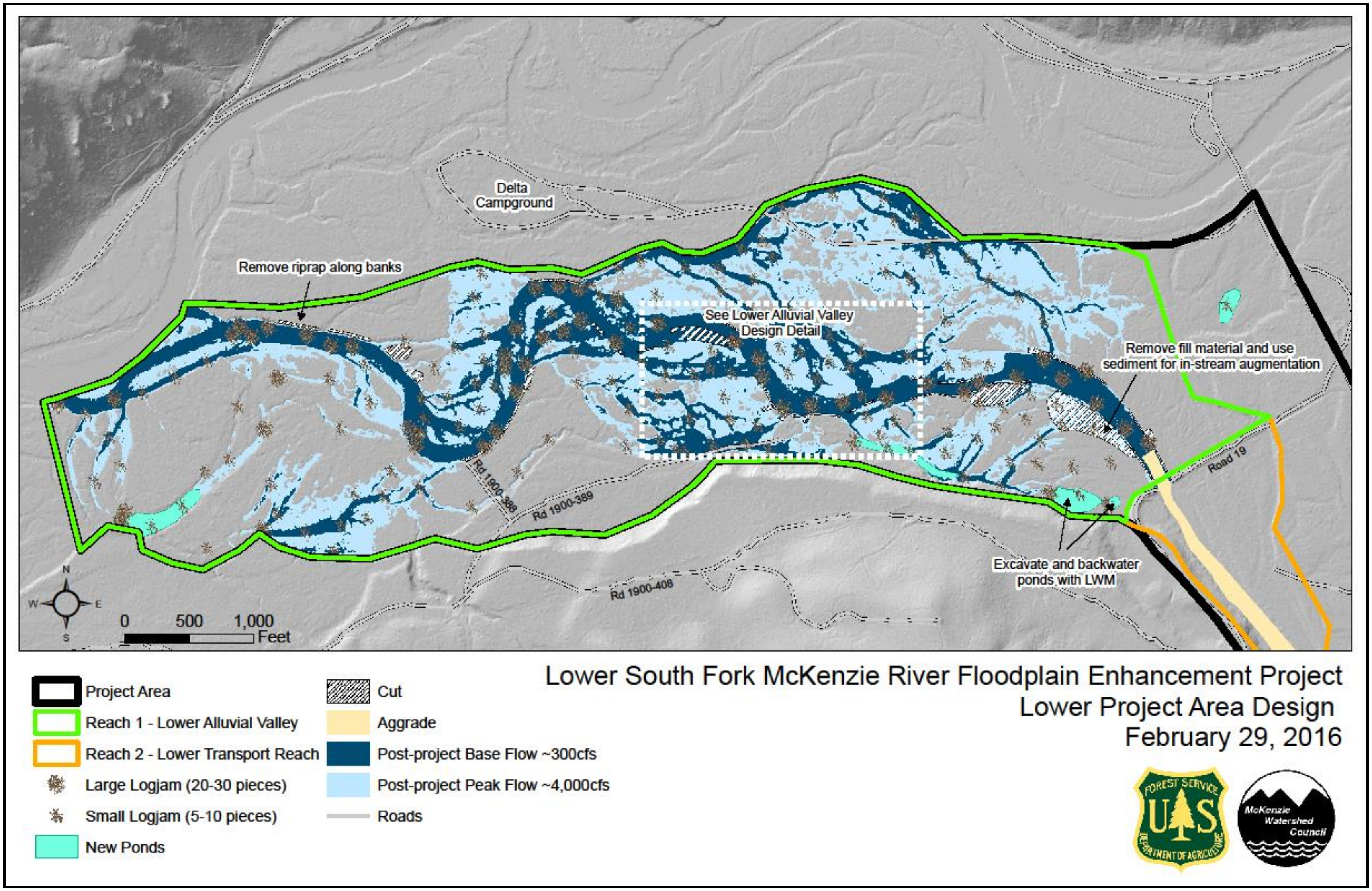


Figure C-2: Design Map 2 – Lower Alluvial Valley Design Detail

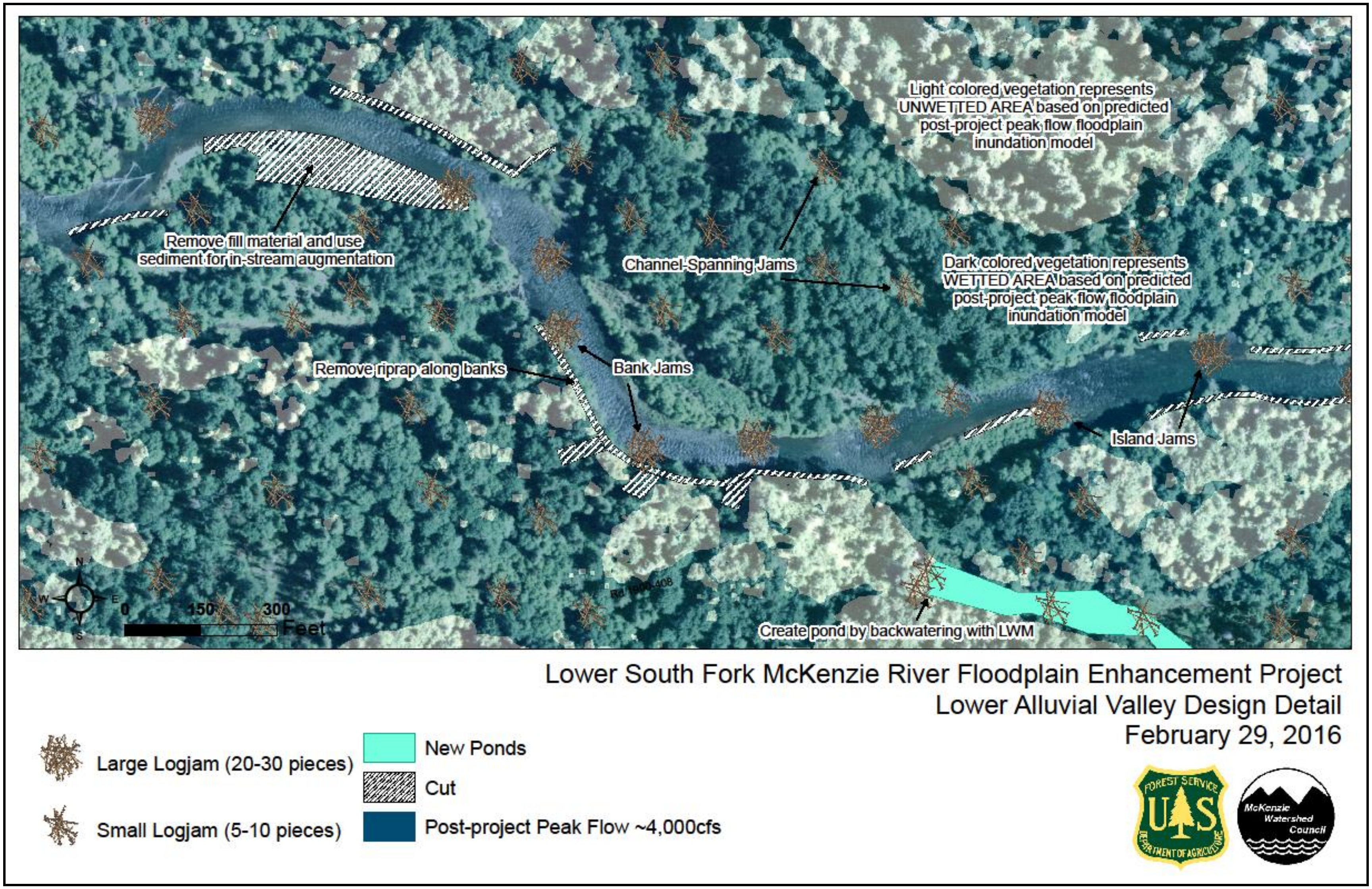


Figure C-3: Design Map 3 – Upper Project Area Design

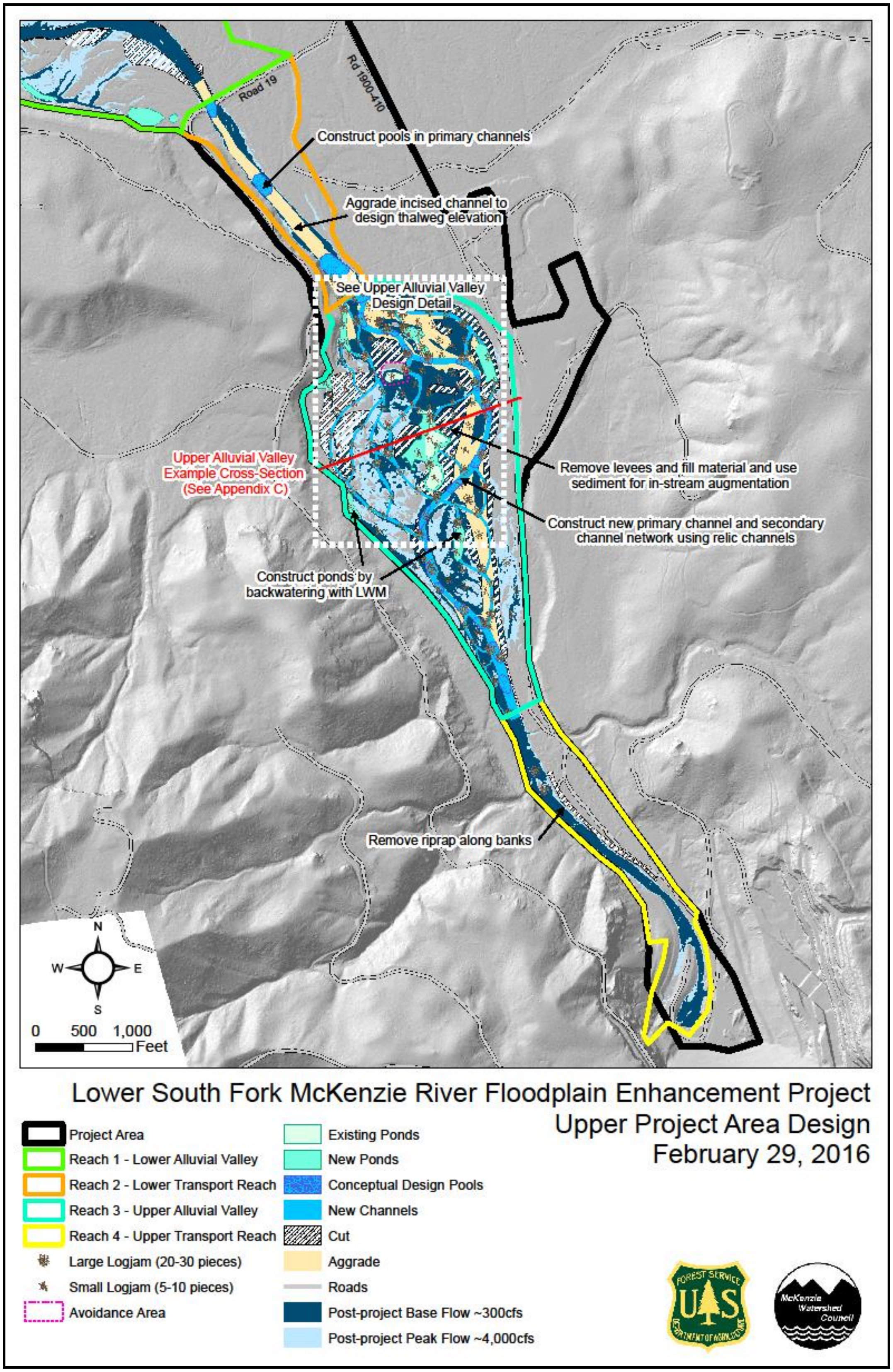


Figure C-4: Design Map 4 – Upper Alluvial Valley Design Detail

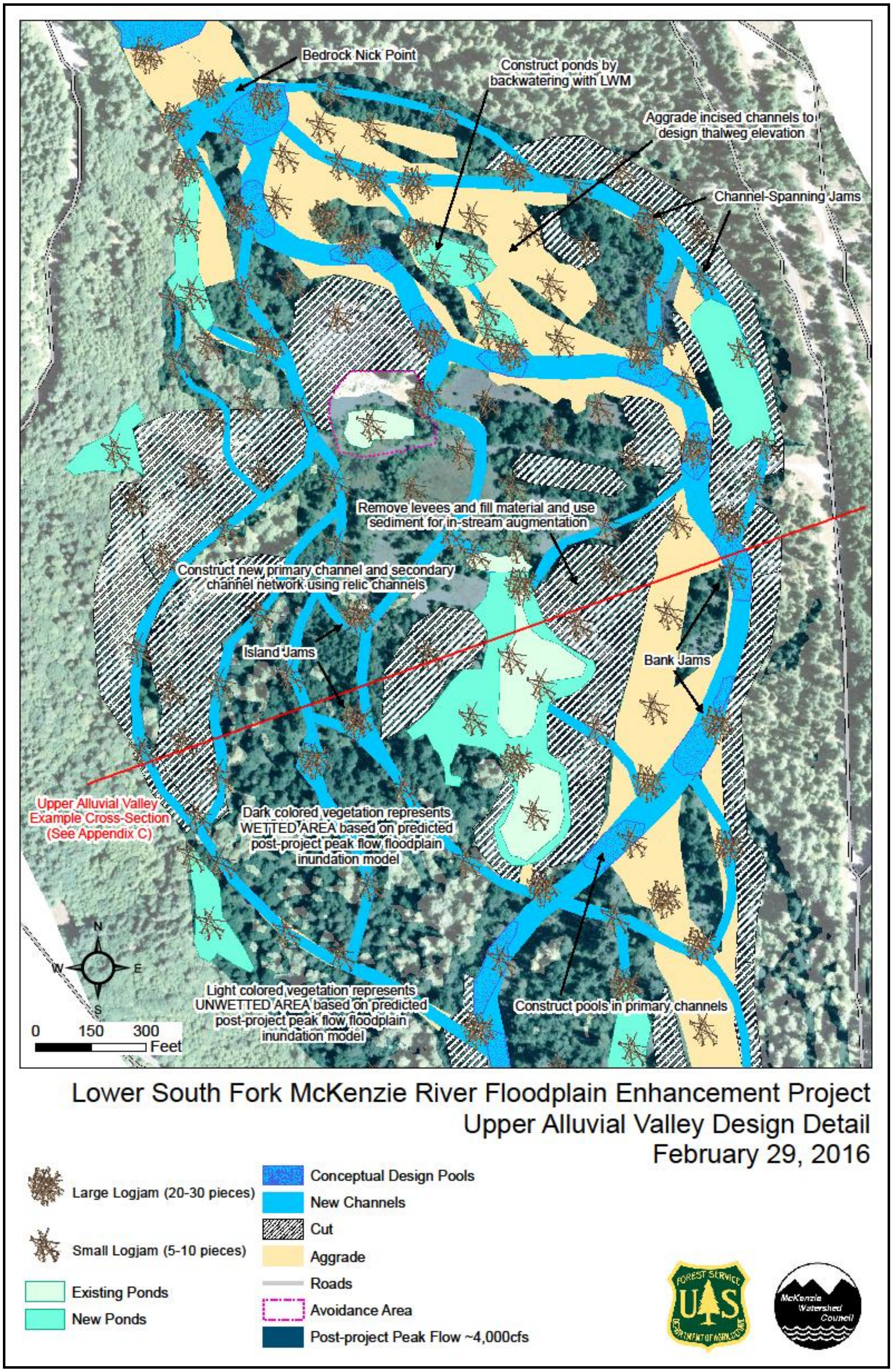


Figure C-5: Design Map 5 – Upper Project Area Logistics

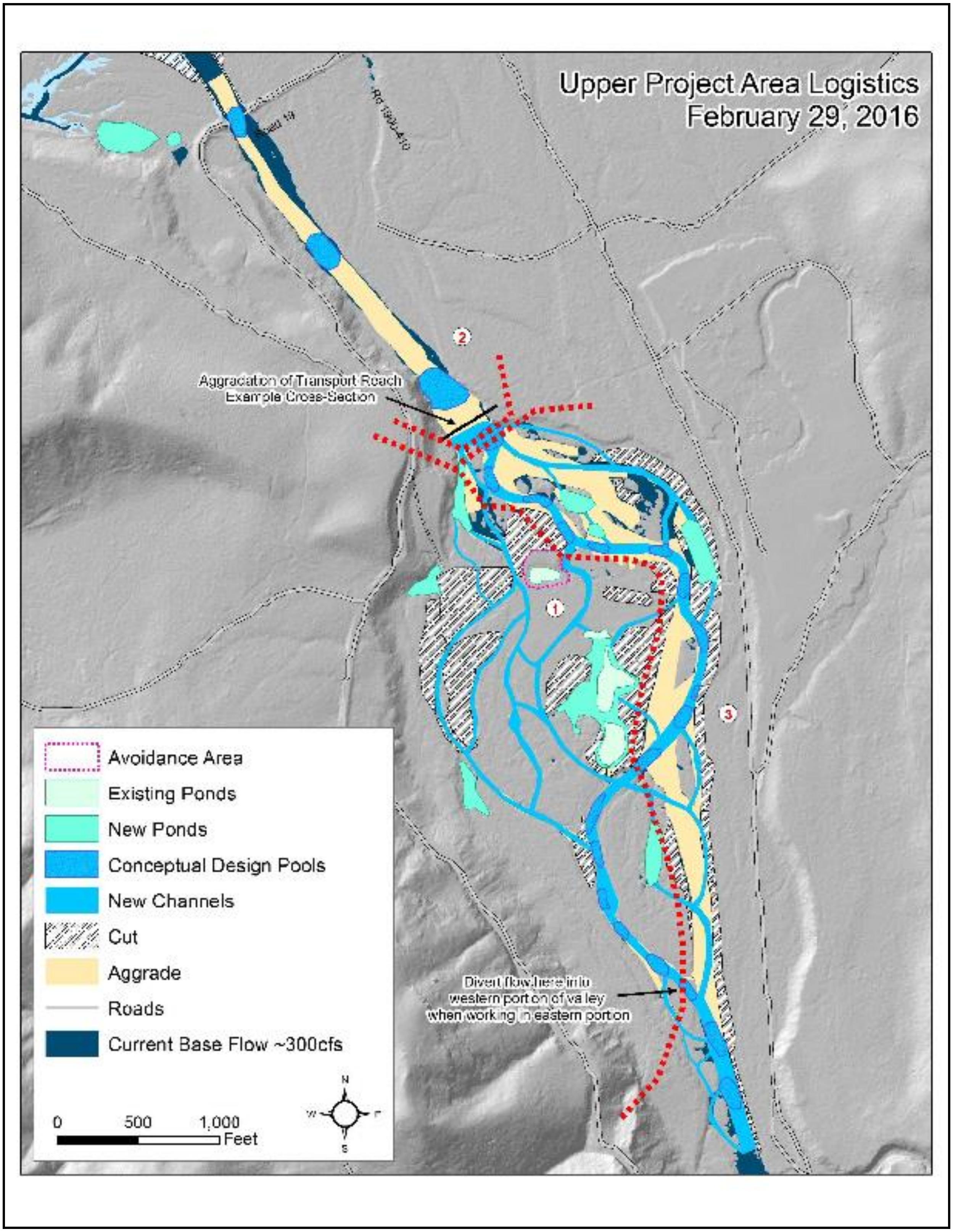
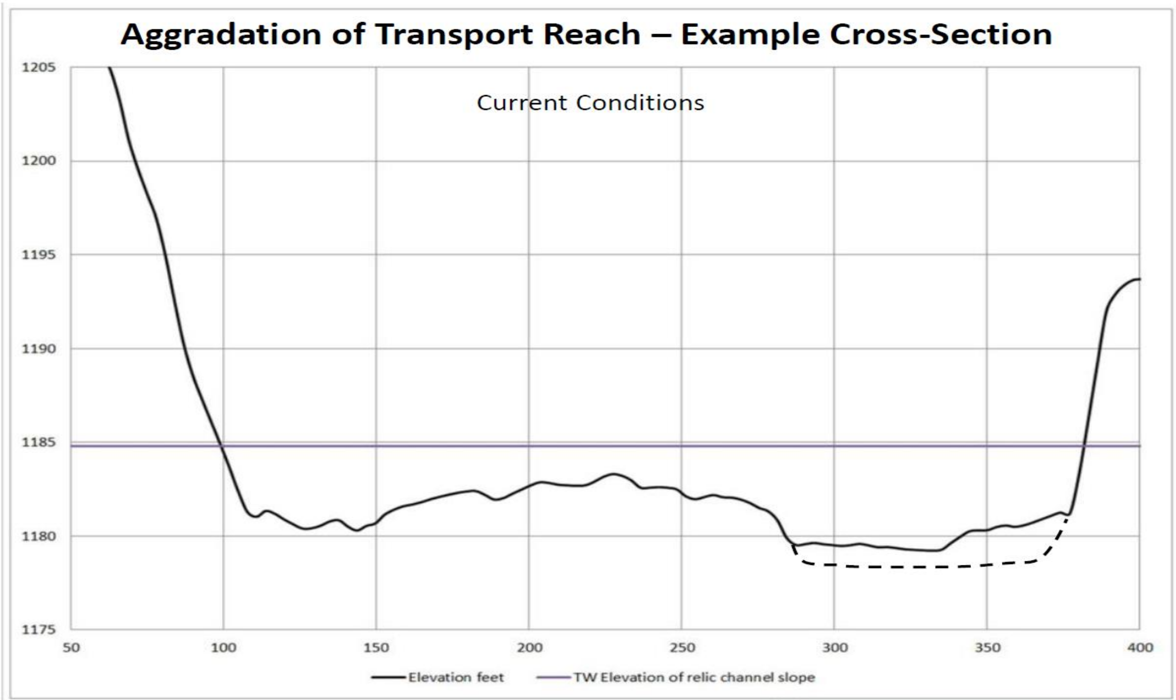
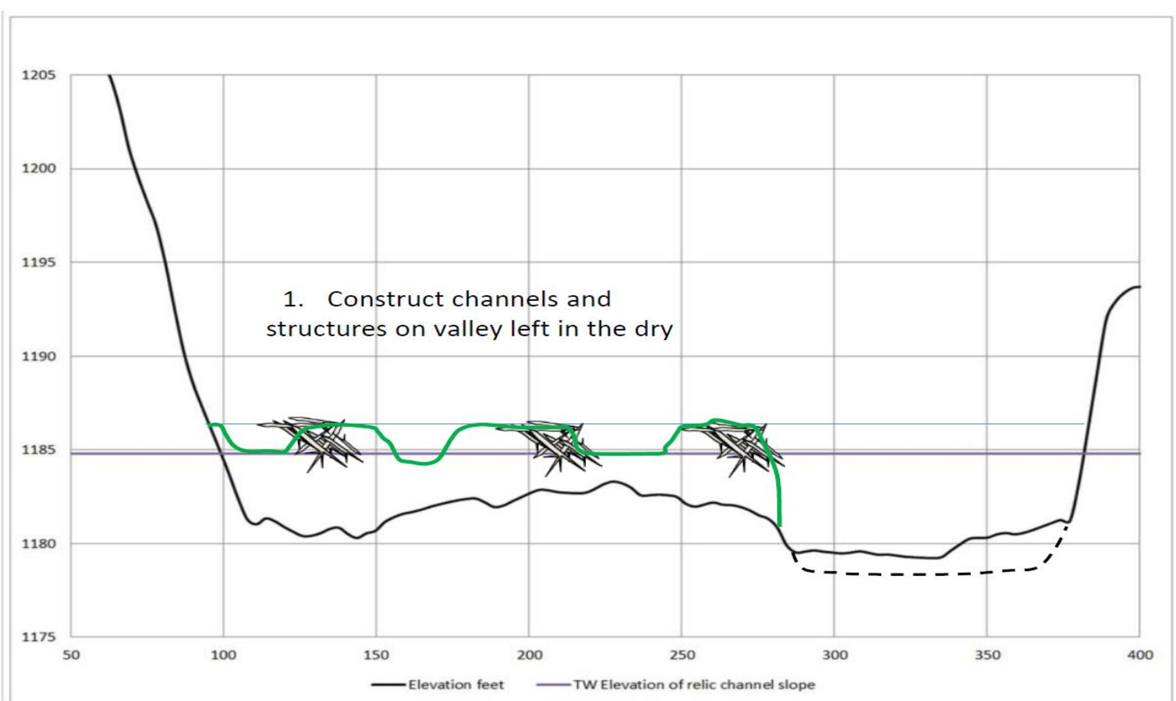
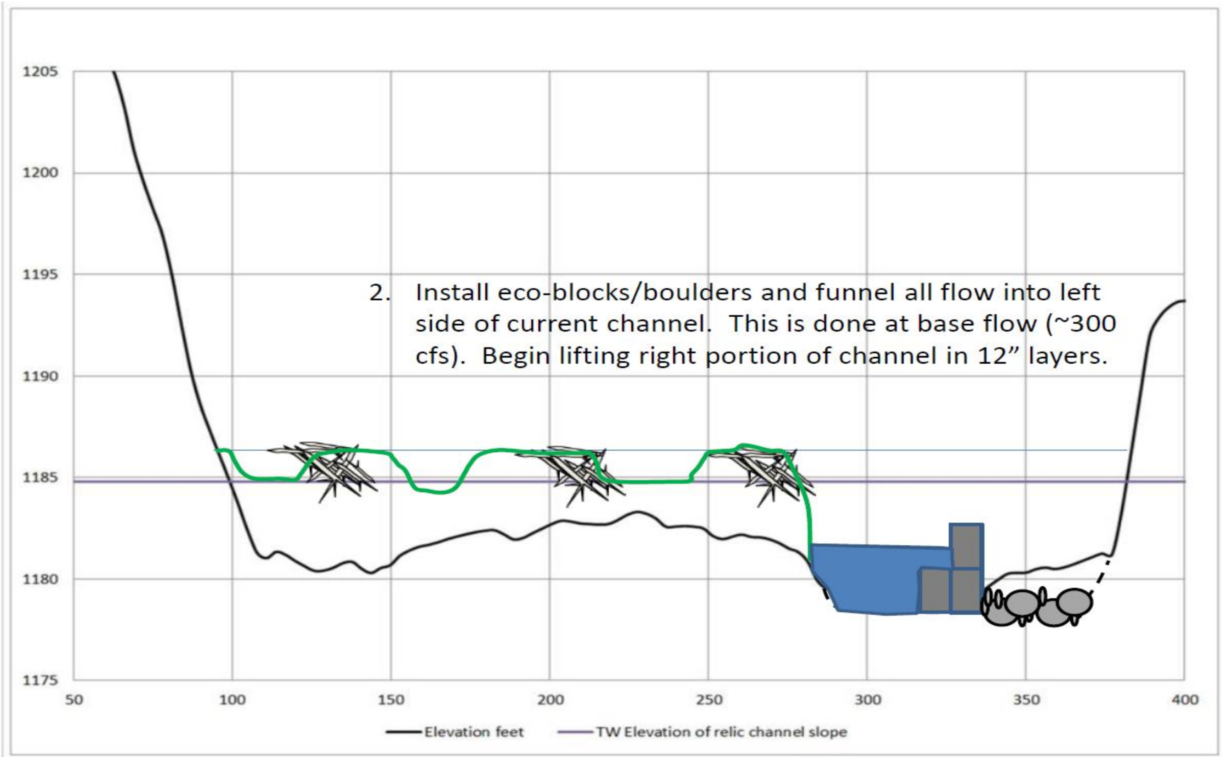


Figure C-6: Aggradation of Transport Reach Example Cross-Section



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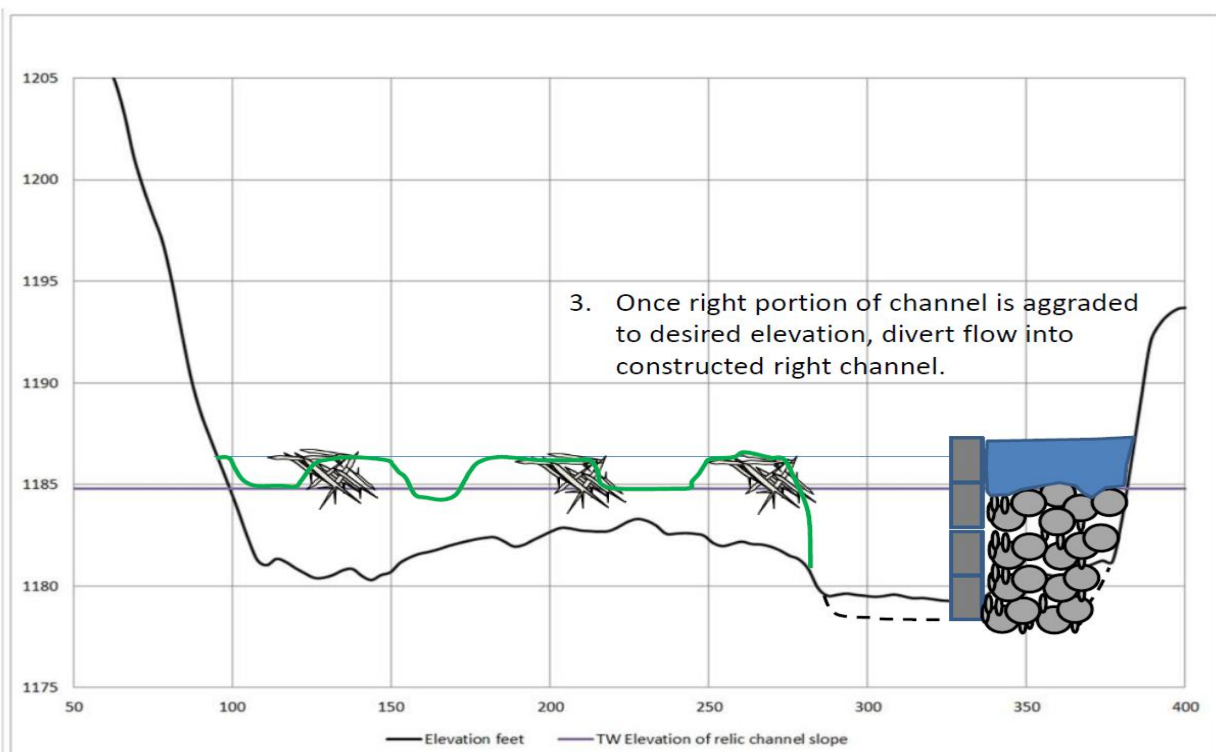
2. Install eco-blocks/boulders and funnel all flow into left side of current channel. This is done at base flow (~300 cfs). Begin lifting right portion of channel in 12" layers.
Elevation feet
TW Elevation of relic channel slope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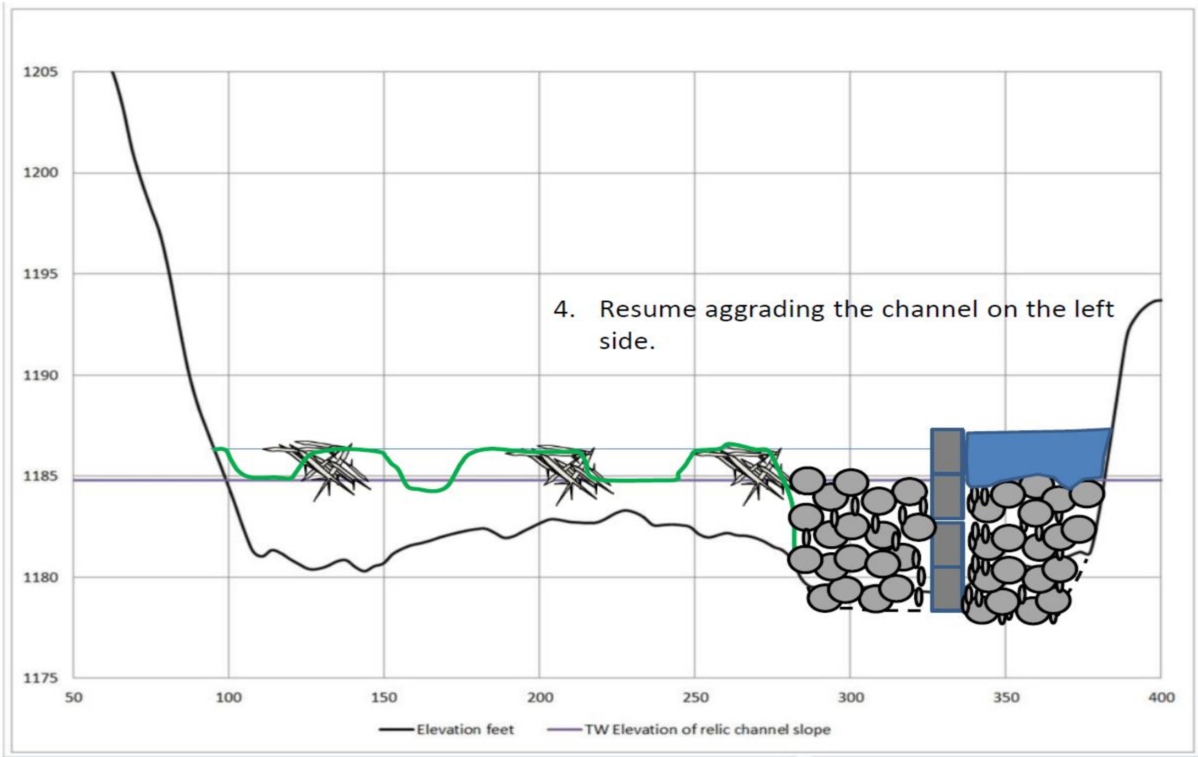
3. Once right portion of channel is aggraded to desired elevation, divert flow into constructed right channel.
Elevation feet
TW Elevation of relic channel slope



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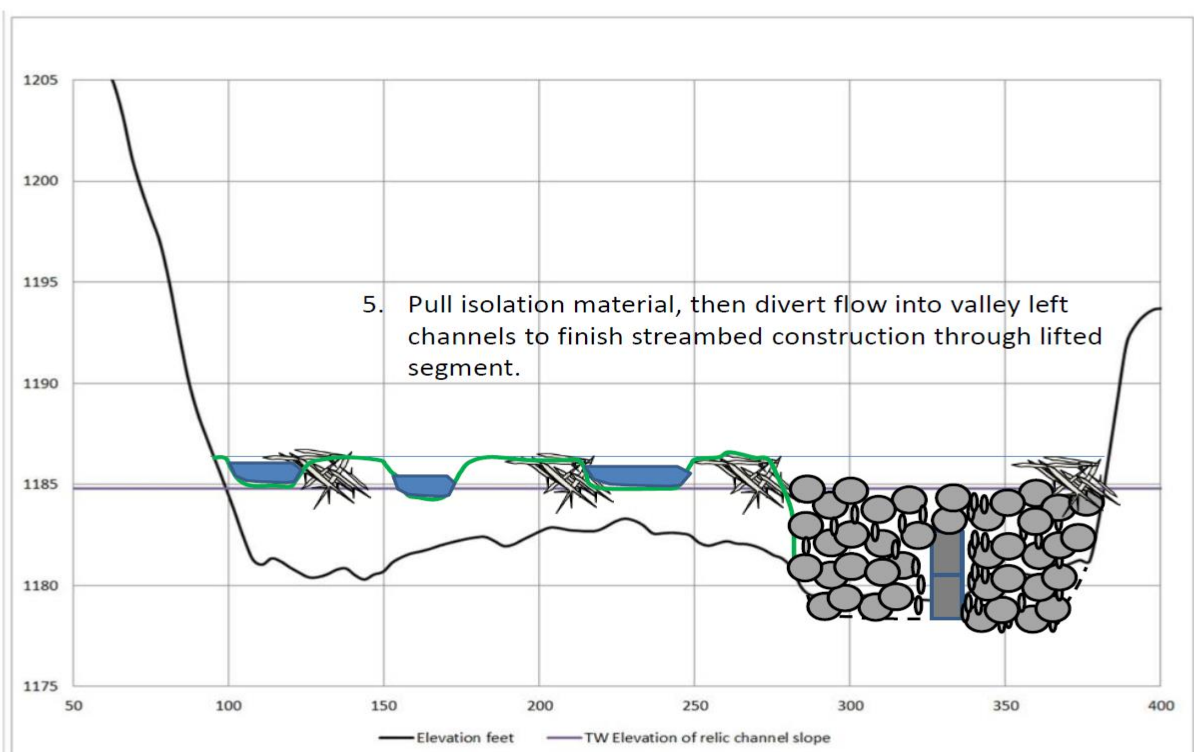
4. Resume aggrading the channel on the left side.
Elevation feet
TW Elevation of relic channel slope



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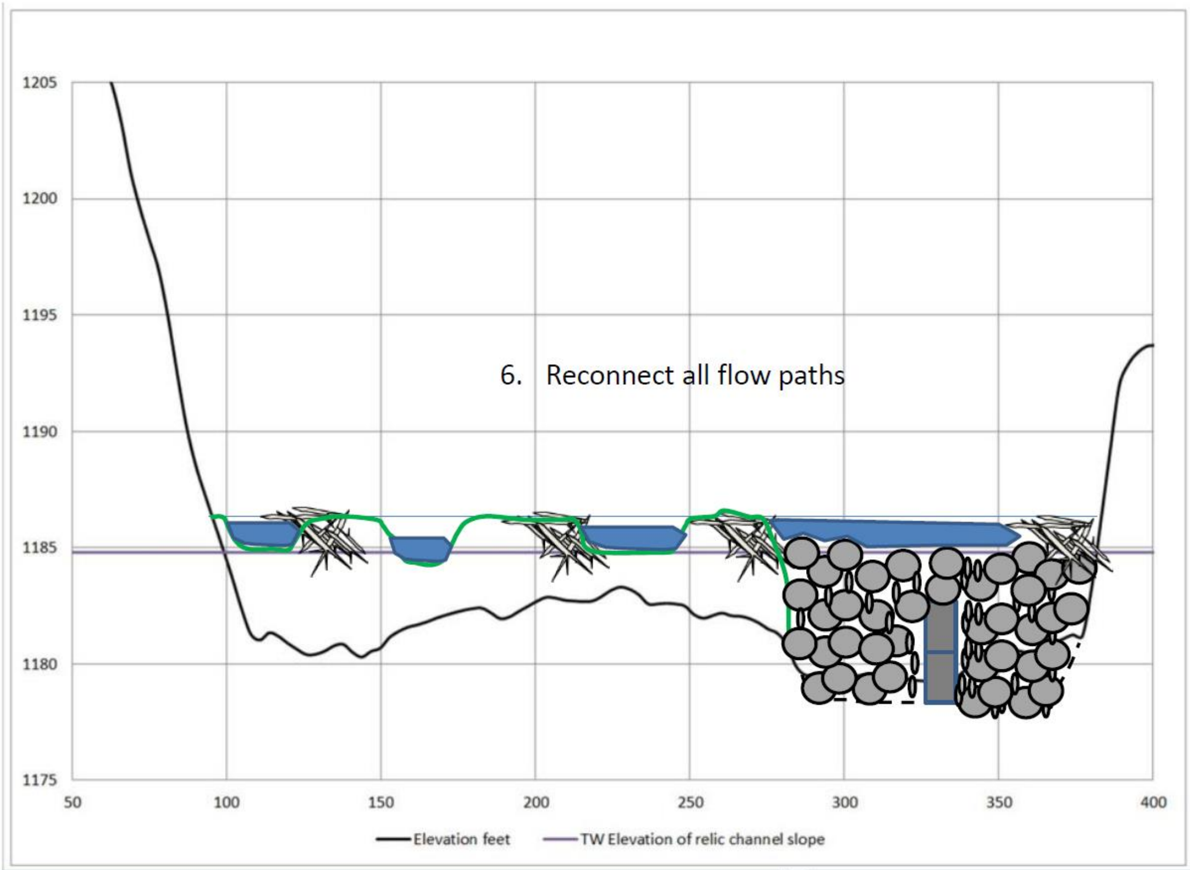
5. Pull isolation material, then divert flow into valley left channels to finish streambed construction through lifted segment.
Elevation feet
TW Elevation of relic channel slope



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6. Reconnect all flow paths
Elevation feet
TW Elevation of relic channel slope

Figure C-7: Upper Alluvial Valley Example Cross Section

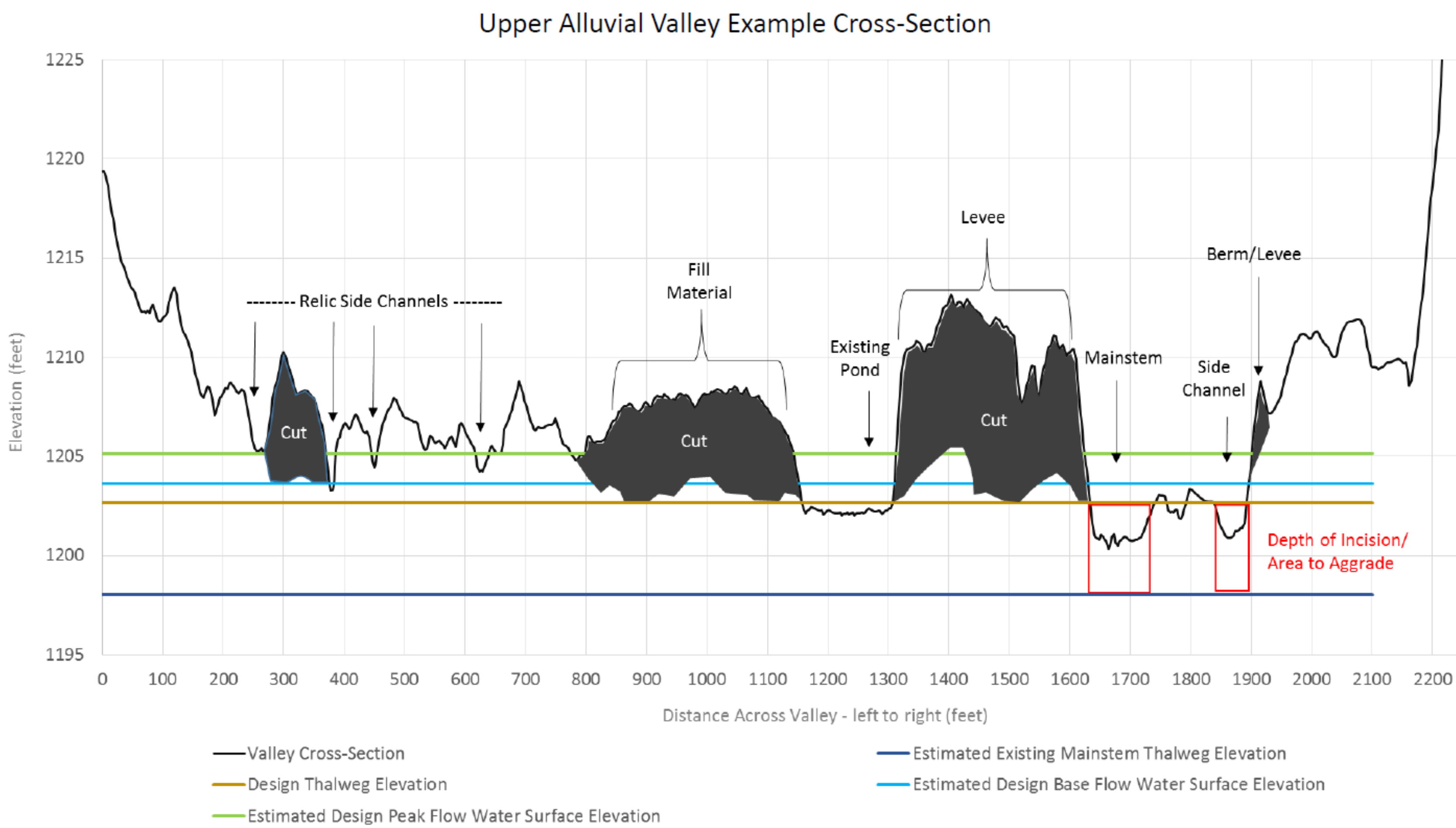
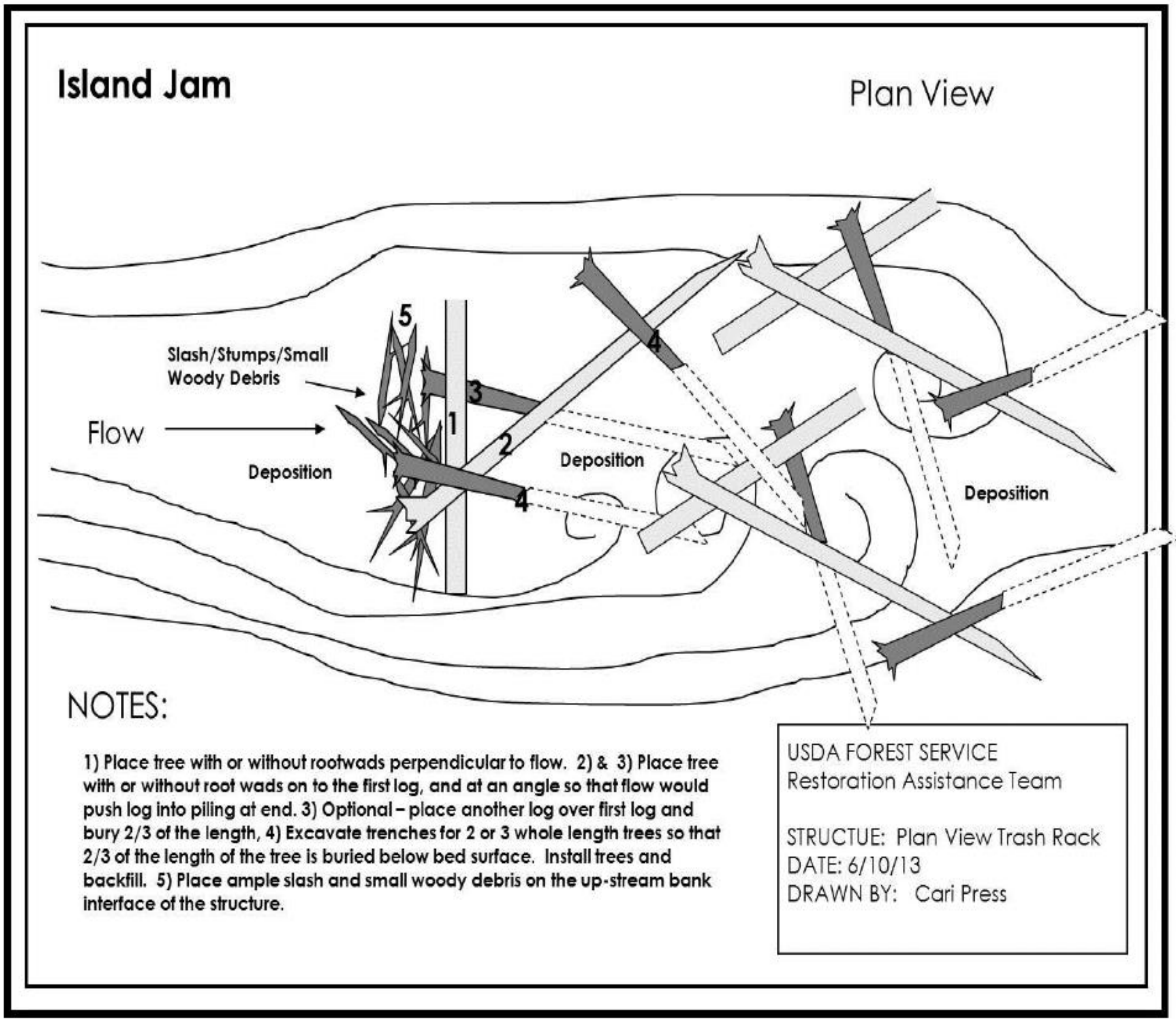
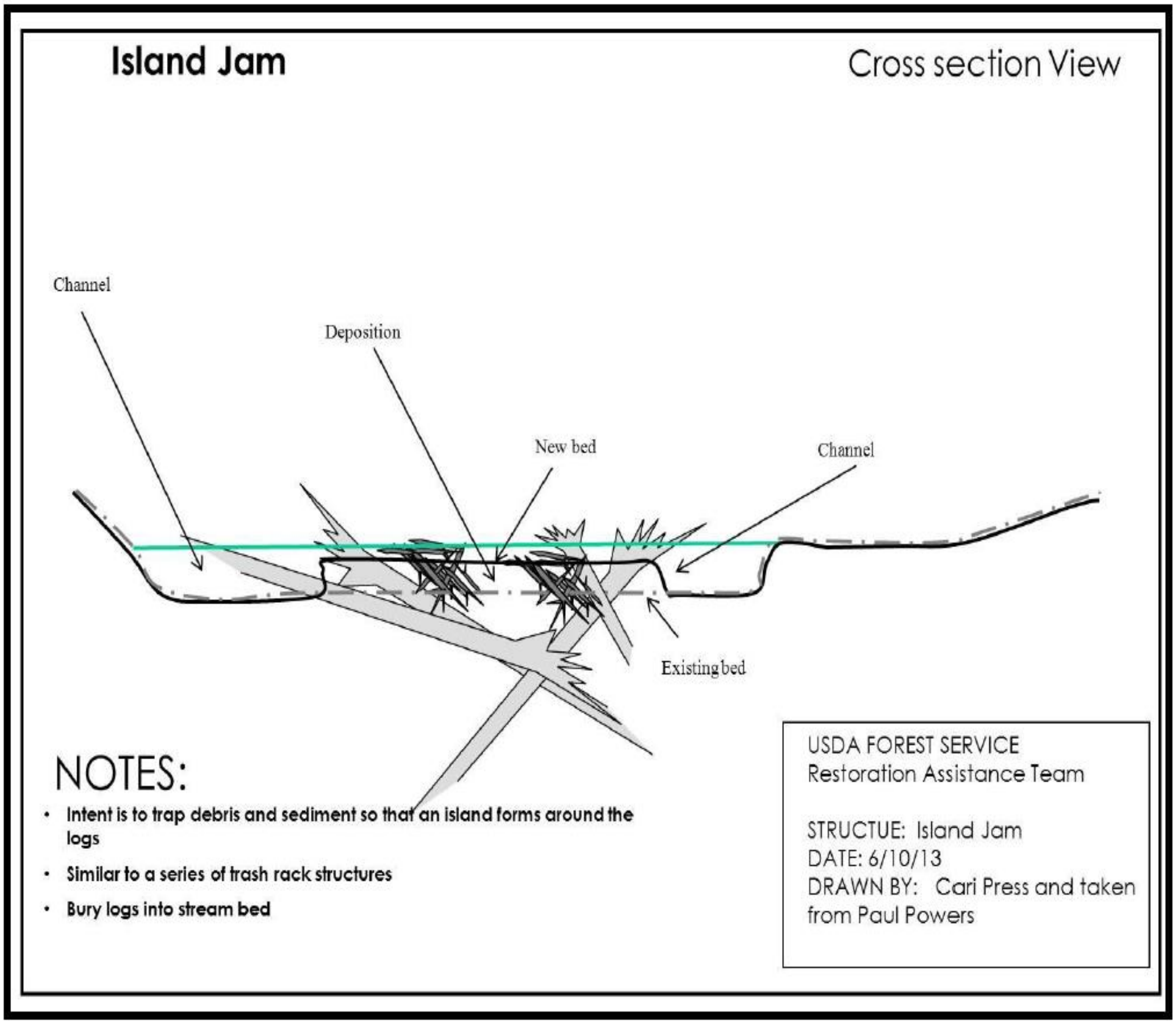
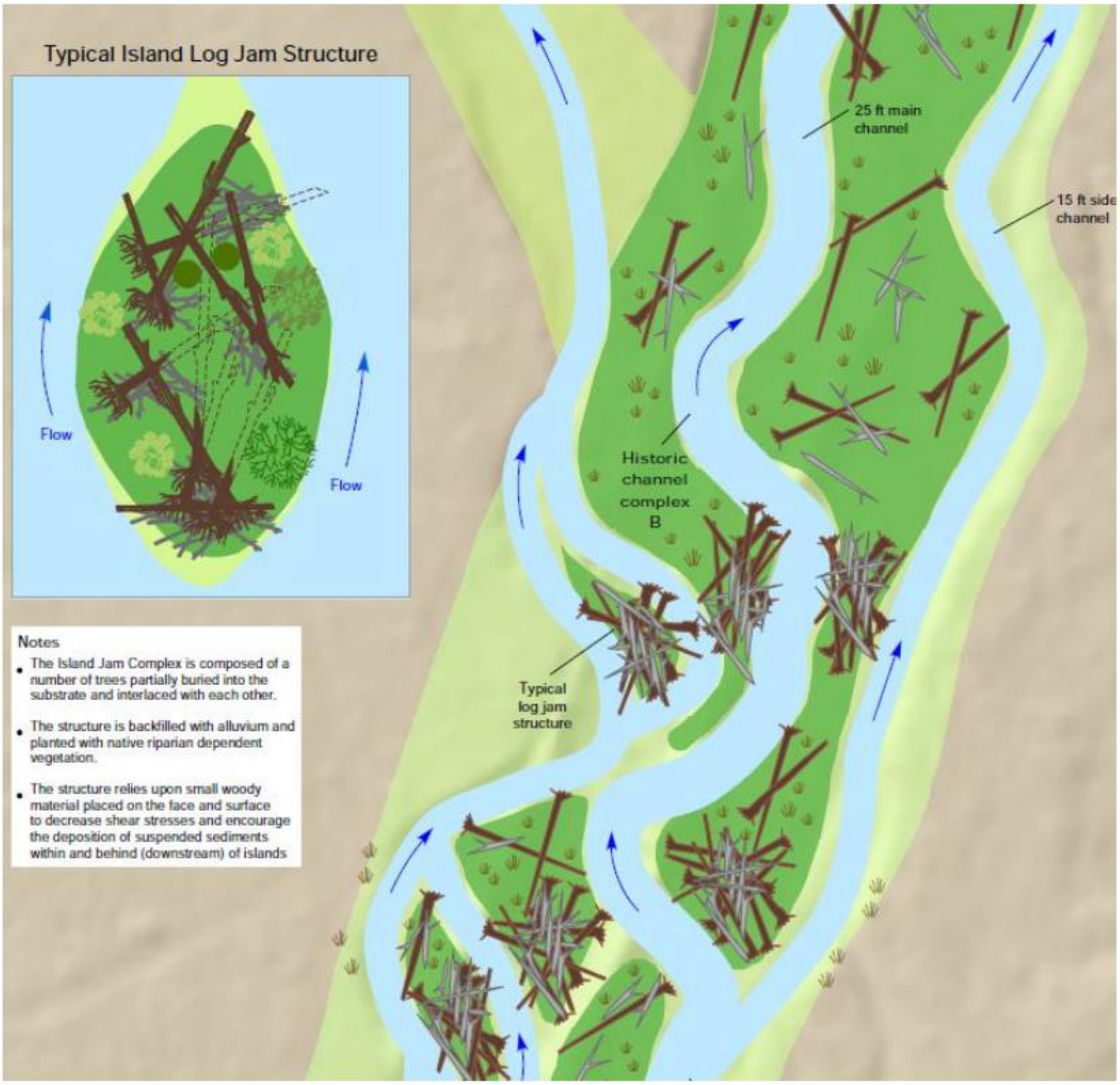


Figure C-8: Design Typicals of Log Jam Structures




Island Jam
Cross section View
Channel
Deposition
New bed
Channel
Existing bed
NOTES:
• Intent is to trap debris and sediment so that an island forms around the logs
• Similar to a series of trash rack structures
• Bury logs into stream bed
USDA FOREST SERVICE
Restoration Assistance Team
STRUCTUE: Island Jam
DATE: 6/10/13
DRAWN BY: Cari Press and taken from Paul Powers

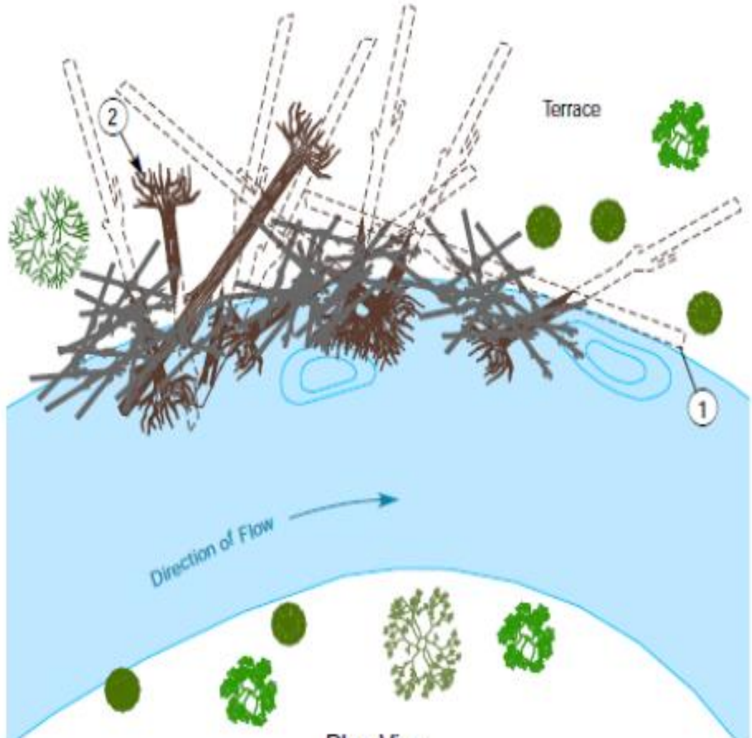

Typical Island Log Jam Structure
Flow
Flow
Notes
The Island Jam Complex is composed of a number of trees partially buried into the substrate and interlaced with each other.
The structure is backfilled with alluvium and planted with native riparian dependent vegetation.
The structure relies upon small woody material placed on the face and surface to decrease shear stresses and encourage the deposition of suspended sediments within and behind (downstream) of islands
25 ft main channel
15 ft side channel
Historic channel complex B
Typical log jam structure

As-built island jam complex on Whychus Creek

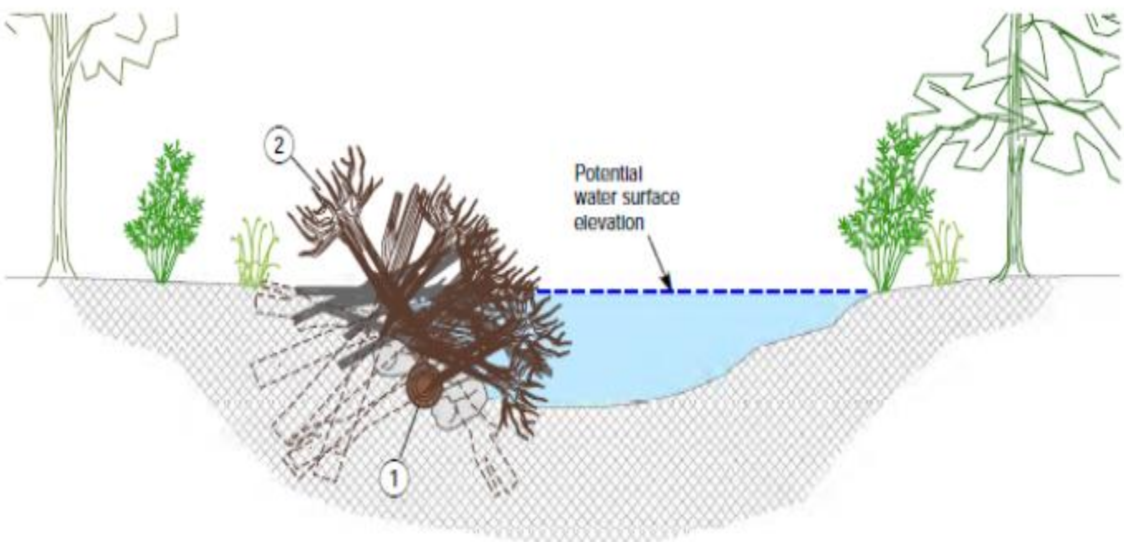
Bank Jam

Notes

1. Excavate toe trenches perpendicular to flow and into bank below bed surface at maximum predicted scour depth. Fill toe trench with aluvium and logs to bed elevation.
2. Excavate torsion log trenches to bed surface elevation. Top of torsion log elevation should exceed 3-5 year discharge return interval elevation.
3. Place / weave additional trees, logs, large boulders, slash or root wads in upstream start of structure.
4. Place ample slash and small woody material on the upstream bank interface of the structure.



Plan View



X-Section View

Channel-Spanning Jams in Secondary Channels