Connor Creek Mouth Feasibility Study Final Report

Prepared By:

Five Counties Salmonid Conservation Program

Jan. 2014

Abstract

This feasibility study was performed to present landowners with design options that attempt to improve adult fish passage through multiple migration barriers in the lower reaches of Connor Creek. These barriers include a 6.3 ft. waterfall, a 146 ft. long tunnel, and a 40 ft. long "chute" at 21.6% grade. GMA Hydrology performed a fish passage assessment which indicates that passage through the Connor Creek Mouth reach is very difficult under a majority of flows due to the waterfall and chute barriers while the tunnel only creates a partial barrier under some flows. Stream assessments performed upstream of the three barriers found no adult migration barriers up to the natural limits of anadromy with steelhead found as far as three miles above the project area. Dr. Chilcote's fisheries assessment chronicled existing fish habitat characteristics and provided data indicating the effectiveness of the barriers in preventing fish migration. Her report also indicates that there is good spawning and rearing habitat upstream of these barriers that are underutilized. A wildlife assessment was performed by 5Counties in Dec. 2014 indicating the presence of wildlife habitat and the protocol and operating periods necessary in order to protect species of concern. An archaeological assessment was performed by archaeologist Bill Rich in Dec. 2014 indicating the lack of historically significant sites within the area of potential effect of the project. The three barriers are located on a single ownership and the landowners have supported the project while providing feedback on concepts and constraints. The design team created three alternatives to improve existing habitat and potentially increase species abundance in the system. Design Alternative 1: Jump Structures involves the formation of a series of jump pools excavated into channel bedrock in order to bypass both the lower waterfall barrier and the upstream chute barrier. Design Alternative 2: Partial Channel Reroute and Jump Structures involves the placement of jump pools at the lower waterfall as in Design Alternative 1, but differs in that a new channel would be created upstream of the tunnel in order to bypass the current channel and chute barrier, returning prior to the tunnel entrance. Design Alternative 3: Complete Channel Reroute involves rerouting the current channel into an adjacent channel, bypassing both barriers and the tunnel. Because of the natural channel limitations for juvenile passage, structural designs for this project did not include juvenile fish passage criteria of a maximum of 6" jump height designs. An exception to fish passage criteria for juvenile passage will have to be approved before a project can be constructed.

Table of Contents

List of Figures

Introduction

This feasibility study examined the reach from the confluence of Conner Creek and the Trinity River upstream for approximately 1,500 ft. Conner Creek is an approximately 3,200 acre watershed located in the middle reach of the Trinity River with elevations ranging from 5,520 ft. at Hayfork Divide to approximately 1,360 ft. at its confluence with the Trinity River. The watershed runoff consists of rainfall in the lower elevations and snow melt in the upper elevations. The watershed transects four geologic formations with approximately the upper 60% being in the Hayfork Terrane. The channel slices through small wedges of diabase and gabbro bedrock before reaching the lowest portion of the watershed. Within the project area the stream cuts into the western edge of the massive Salmon Hornblende Schist formation that forms the North Fork of the Trinity River and Canyon Creek watersheds. The schist parent material is "moderately well foliated amphibolites facies metamorphic rock consisting of hornblende, epidote, and albite. It is an erodible unit, releasing large number of clay-sized amphibole crystals into the Trinity River." (DWR, 1980). The native soils at the project site were most likely Pardaloe-Dedrick association which supported both mixed-conifer and hardwood forest stands. Because the mining of the area removed nearly all native soils present-day soils are currently classified as Xerothents: shallow, well-drained mixes of rock and material weathered from the schist parent material (NRCS, 1998). Permeability is slow and runoff is rapid. Available water holding capacity is very low due in part to the shallow nature of the soils.

Land use immediately surrounding the project area is rural residential with the approximate upper 50% of the watershed being managed by the Shasta-Trinity National Forest (STNF). A significant portion of that land lacks roadways. The Eagle Fire burned the upper 42% of the Conner Creek watershed in 2008 with much of that burn being high intensity and stand replacing. Potential watershed impacts downstream of the 2008 burn area may be significant, especially in the first two decades following the fire.

Stream and habitat surveys conducted on Conner Creek in 1974, 1979, 1980, 2006 and 2011 (Taylor 2006, STNF 2011, Chilcote 2014) found Conner Creek has cool-water perennial flows and can provide refugia for both steelhead and coho juveniles. The habitat surveys noted several young of the year salmonids and resident trout as well as 1+/2+ steelhead (Taylor, 2006). The Trinity River and its tributaries, including Conner Creek, are designated Critical Habitat for the Southern

Oregon-Northern California Coast (SONCC) coho salmon. The SONCC coho is both a state and federally listed Threatened species. While coho may use the lowest portions of Conner Creek, most of the watershed is not accessible to this species due to man-made barriers and steep stream channel gradients. However, the "habitat is very capable of supporting steelhead and coho… During our surveys we have only found juvenile steelhead/resident rainbow trout rearing here, but the habitat appears suitable for use by coho salmon. In 2001 the Trinity River experienced a very good run of coho salmon in conjunction with excellent migration conditions, coho salmon used many similar tributaries in the surrounding area but coho were not recorded to be found in Conner Creek, presumably due to lack of access" (L. Everest, 2008).

Trinity County in partnership with the 5C Program has undertaken the removal of two migration barriers on Conner Creek upstream of this project area and downstream of the Eagle Fire burn area. At Conner Creek Rd. a concrete box culvert with a fish weir and a 2 ft. jump at the outlet was a partial barrier to adult salmonids and a complete barrier to juveniles. This barrier was removed in October of 2011 and replaced with a 24 ft. wide bridge. A 10 ft. corrugated metal pipe at Red Hill Rd. upstream 0.2 miles from the Conner Creek Road project was a partial barrier to adults and a complete barrier to juveniles. It was replaced in 2012 with an 18 ft. multi-plate arch. The crossings upgrades were done to increase capacity to allow for the 100 year storm flows and fire associated debris (logs and rock) to be naturally transported downstream as well as to allow fish passage. These projects were funded by numerous partners including TRRP, US Forest Service, US Fish and Wildlife Service, NOAA/NMFS, CA Coastal Conservancy, Fish and Game, Trinity RAC, and Trinity County.

The 1,500 ft. project stream reach occurs within a patented mining claim that is now held in fee title by the Stewart family. The property was originally part of the Montezuma claim of the Goldfield Consolidated Mines Company. In 1946 a partnership composed of Ward Hill, C. M. McCartney, and H. C. Loft of Junction City leased a portion of the Montezuma claim. The bedrock was mined 18 to 20 inches deep with a bulldozer. The material was pushed into a mill race cut into the bedrock 18 to 20 feet deep for a length of about 145 feet (refer to Figure 1). A tunnel was cut through the hillside at the lower end of the mill race (Figure 2) and the stream was diverted permanently into this location at that time. The tunnel and 20 ft. deep chasm form the upper end of this project. Mining ceased in 1954.

The current channel within the mined reach was cut through Salmon-Hornblende Schist bedrock parent material as part of the mining operations. The channel in this reach consists of step pools with vertical walls (Figure 1). The vertical walls provide shade over the channel and there is a sparse mix of alder and cottonwood trees growing within the canyon. The age of the trees in the canyon (approximately 17 years old) suggest that the canyon scours in response to large flow events such as the 1997 New Year's Day storm. Blackberry, ponderosa pine, grey pine and incense cedar grow on the banks above the channel.

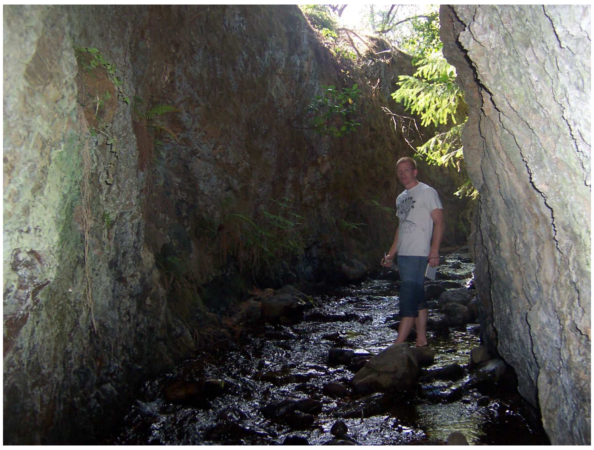


Figure 1 – Cut through 18 ft. of schist parent material (Left) **Figure 2 –** Tunnel under Quail Rd. (Right).

It was recognized early on that any design may require an exception of National Marine Fisheries Service Anadromous Salmonid Passage Facility Design Guidelines (NMFS, 2008). To address possible design options and determine if an exception was warranted, an interdisciplinary team was developed consisting of engineering and biological staff from the 5C Program (Claire Lindstrand, Dimitri Dolci, Mark Lancaster, Jacob Hymas), National Marine Fisheries Service (Wes Smith), CA Department of Fish and Wildlife (Kate Grossman, Mark Smelser, Bernard Aguilar), US Forest Service (Eric Wiseman), Trinity River Restoration Program (Dave Gaeuman), Consulting hydrologist Graham Matthews, and Consulting Fisheries Biologist Samantha Chilcote. In addition, William Rich and Associates was retained to assess cultural resources and 5C staff wildlife biologist Carla DeJuilio assessed wildlife to identify other resource factors in the design process.

Evaluative Criteria

Total Station Survey[1]

A total station survey was performed by 5C engineering staff in 2014 to analyze the existing channel characteristics and to provide geometric data to use in hydraulic and fish passage assessments. The team used a Nikon A20 total station, Bear Rod, and Seco prism to perform the survey. The survey encompassed approximately 1300 ft. of Connor Creek extending upstream from the mouth. The survey included thalweg, cross sections, and topographical data through this reach. This survey identified the geometric properties of the migration barriers in this reach including one downstream waterfall of 6.3 ft. (Figure 4), a 146 ft. long tunnel under Quail Rd. (Figure 2), and an upstream chute of 21.6% channel grade (Figure 5). The overall average channel grade through the project area is 5.8%. This data can be seen in Figure 3 and in the excel file Attachment 1.

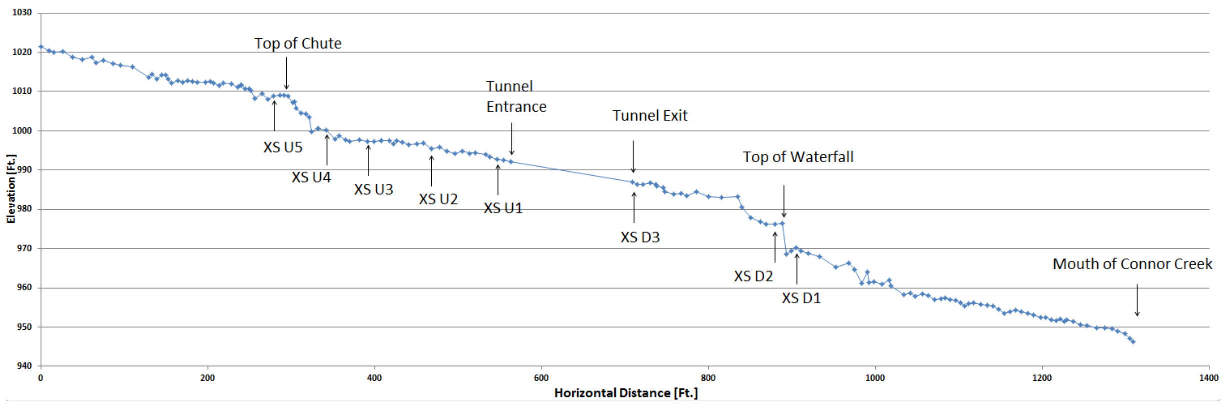

Figure 3 - Long profile.

[1] No property line surveys were done as part of this effort. Approximate property lines were noted from Trinity County Assessor Office records. In 2013 a professional surveyor flagged the common boundary between the Stewart parcels (project area) and the Palmer parcel, the only other adjacent private property. Based on that survey information it was determined that the project lies on the Stewart property.

Fish Passage Assessment

GMA Hydrology was contracted to conduct a fish passage assessment through the lower reach of Connor Creek which can be found in Attachment 2 – *Connor Creek FishXing Memo*. The assessment used FishXing software, the survey data collected by 5C, and flow data from USGS methods for determining magnitude and frequency of floods in California (Gotvaldt 2012). Key results include that all sites analyzed fail to meet passage requirements for juvenile salmonids. The downstream waterfall fails to meet CDFW passage criteria and moderate fish ability criteria, but meets criteria for maximum fish ability 79% of the time. The upstream chute fails to meet CDFW passage criteria and moderate fish ability criteria, but meets criteria for maximum fish ability 49% of the time. The tunnel under Quail Rd poses less of a threat, meeting CDFW criteria 5% of the time, moderate fish ability 35% of the time, and maximum fish ability 95% of the time. The assessment indicates that Connor Creek Mouth is "a rather difficult stretch of creek to navigate for the majority of fish at fish migration flows" (Matthews 2014).

Figure 4 – Downstream 6.3 ft. waterfall**. Figure 5** – Upstream chute barrier at 21.6% grade.

Fisheries Assessment

Dr. Chilcote conducted a fisheries assessment survey in January of 2014 and submitted a report to 5C, shown in Attachment 3- *Connor Creek Mouth Fish Passage Enhancement Feasibility Study - Fisheries Assessment.* Dr. Chilcote's analysis divides the reach into three sections: Reach 1 spans from the mouth of Connor Creek to the tunnel outlet, Reach 2 spans from the tunnel outlet to the upstream chute barrier, and Reach 3 spans from the chute to the upstream survey extents. Refer to **Error! Reference source not found.** to view the functionality of habitat elements in the three reaches.

Table 1: "Properly Functioning (PF), Functioning At Risk (FAR), and Not Properly Functioning (NPF) for Continuous and Point Measure indicators in each study reach" (Chilcote 2014)[2]

	Reach 1			Reach 2			Reach 3		
	PF	**FAR**	**NPF**	**PF**	**FAR**	**NPF**	**PF**	**FAR**	**NPF**
Pool	X					X	X		
LWD	X			X			X		
Off-channel Habitat		X				X		X	
Temperature	X			X			X		
Chemical contaminant and nutrients	X			X			X		
Substrate		X			X				X

"Reaches 1 and 3 provide higher quality salmonid habitat than Reach 2 due to higher pool frequency, good overhead cover from vegetation, in-stream wood, and cooler water temperatures" (Chilcote 2014). In addition to the lack of good habitat within Reach 2, the waterfall in Reach 1 and the chute section in Reach 3 appear to be significant barriers to upstream fish migration. Snorkel surveys conducted within the three reaches yielded Rainbow/steelhead complexes (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus* kisutch), and one aquatic vertebrate species, Pacific Giant Salamander (*Dicamptodon* spp) (Chilcote 2014). Of these four observed species, only rainbow trout were common to all of the surveyed reaches, and thus this species was used for analysis of differences in size classes between

[2] "The APA (Analytical Process for Developing Biological Assessments for Federal Actions Affecting Fish Within the Northwest Forest Plan Area) was used to evaluate habitat conditions as Properly Functioning, Functioning At Risk, and Not Properly Functioning. Thresholds for evaluation are in Appendix B. Not all measures had thresholds established by the APA. Only those which had thresholds are included in the table." (Chilcote 2014)

reaches. While juvenile size/age fish of were relatively common in Reach 1 pools, no brown trout, Chinook salmon or coho salmon juveniles were observed upstream of the waterfall barrier. "[The lack of juveniles] indicates adults are not consistently bypassing the waterfall area in order to spawn and populate the area with juvenile offspring, despite the presence of suitable upstream habitat" (Chilcote 2014). "Restoration of streambed to more natural conditions within Reach 2 and improvement of fish passage conditions at both barriers would likely allow for increased salmonid colonization in Conner Creek as well as enriched size class structure and diversity in the upstream watershed" (Chilcote 2014).

Stream Connectivity Assessment

The mouth of Conner Creek consists of a boulder/cobble delta that was purported to force stream flow subsurface, disconnecting the stream from the river. Review of the mouth during critical low-flow summer conditions indicated a small delta with continuous flows connecting the stream and river. Flows were too low in the peak of the drought of 2014 for adult fish to move into the stream in summer. This is not considered a significant long-term limitation because adults are not migrating into the streams during the summer low-flow period. In some years the combination of drought, water diversion[3], and delayed arrival of fall precipitation may preclude adequate stream flows to attract spawning coho into the stream system. This lack of adequate attraction flows in these situations is not unique to Conner Creek.

Salmon migration into Conner Creek from the Trinity River was identified as an early design consideration. Residents and restorationists reported that the confluence of Conner Creek and the Trinity River was dynamic and up to the early 1970's the mouth could move as much 100 ft. in a single year (B Stewart, pers comm, 2013). They also reported that the mouth continued to migrate in a narrower range until the 1990s. This migration of the mouth could cut off connectivity to the river during migration periods. A review of historic aerial photos of the channel location between

[3] Several diversions on Conner Creek have been estimated by area residents to have reduced in-stream flows by as much as 50% in the past (B. Stewart pers comm 2014). Following the 2008 Eagle Fire complex the Forest Service as part of the restoration of the Red Hill Lake subdivision water diversion required the diverters to reduce the amount of water diverted into the lake. Portions of the Red Hill Lake overflow return to Conner Creek upstream of the project, but a significant portion is diverted into a separate unnamed stream west of the Conner Creek drainage.

1944 and 2011 was done to try and map the stream and mouth migration. Aerial photo review and historic mining information now shows that the mouth tended to migrate west from its 1944 location until approximately 1971.

This channel migration was most likely associated with the 1940's mining that moved the entire stream channel into the tunnel and into a new channel. It is probable that the stream cut a new channel for the first several decades following the 1940's-50's mining in response to storm flows. The 1974 flood, considered a 100 year storm, was probably the most significant contributor to creating the current channel location. The current mouth location appears to be relatively stable, having been in place since 1971 with minor migration within only a 50 ft. area. Given the level of past disturbance and future effects of the 2008 stand replacing Eagle Fire there is no assurance that the mouth of the stream will remain in its current location in response to large storm flows. At this time, however, the mouth is stable and connectivity to the river has been observed during the life of this study.

The high flow releases from Lewiston Reservoir in 2011 appear to have reduced the rock delta "barrier" historically reported at the mouth of Conner Creek. Observation during the August 2013 increased flow releases (2,200 cfs at the Junction City gauge) confirmed connectivity between the river and Conner Creek in those flows. In addition reduced diversions in the stream itself may be contributing to improved connectivity of the stream to the river. However, the in-stream conditions on fish flows continue to limit the use of the stream by anadromous salmonids upstream of the lower waterfall, especially coho salmon.

Wildlife Assessment

Carla De Juilio (Wildlife Biologist) completed a wildlife assessment, analyzing the potential effects of the project on wildlife species and their habitats. A detailed description can be found in Attachment- 4: *Wildlife Biological Assessment/Biological Evaluation: Conner Creek Mouth Fish Passage Enhancement Project. December 2014*. Wildlife species analyzed include those listed under the federal *Endangered Species Act* (ESA), the *California Endangered Species Act* (CESA), and California Species of Special Concern (SSC). The following species listed under the ESA were considered and analyzed: Northern spotted owl, Western yellow-billed cuckoo, and fisher (West Coast DPS). The project is not located within or near suitable nesting/denning habitat for any species listed under the ESA therefore habitat and individuals of those species will not be impacted. The following species listed under the CESA were considered and analyzed: willow flycatcher, bald eagle, wolverine, Townsend's big-eared bat, and Trinity bristle snail. Suitable habitat is present for three species: bald eagle, Townsend's big-eared bat and Trinity bristle snail. In order to protect the Trinity bristle snail, protocol level surveys were conducted during the fall of 2014. No Trinity bristle snails were found within the project area. In order to protect the Townsend's big-eared bat, a Limited Operating Period (LOP) from April 1-August 1 will be utilized for any work within or near the tunnel to prevent noise and other human disturbance during the maternal roosting season. To protect the bald eagle, a Limited Operating Period (LOP) from January 1-August 1 will be utilized to prevent noise and other human disturbance related to project activities during the breeding season. If construction is scheduled to occur prior to August 1, preconstruction surveys for Townsend's big-eared bats and bald eagles will be conducted by a qualified wildlife biologist prior to construction activities. If Townsend's big-eared bats are found within the tunnel, construction involving boulder placement within the tunnel will be postponed until the biologist has determined that the bats have left. If an active bald eagle nest is found, CDFW will be notified and an appropriate sized buffer will be placed around the nest. Construction will be postponed within the buffer until the biologist has determined that nestlings have fledged, or breeding has failed. Due to the prescribed LOPs, the project will have no effect on any species listed under the CESA or their habitat.

Impacts to California Wildlife Species of Special Concern (SSC) were also analyzed. The project may impact individuals but would not cause a trend towards federal listing or a loss of viability for the yellow warbler, yellow-breasted chat, Pacific tailed frog, foothill yellow-legged frog and Western pond turtle. No mitigation measures are necessary given the Resource Protection Measures and BMPs incorporated into the project design. The project will have no impact on the golden eagle, American peregrine falcon, Northern goshawk, olive-sided flycatcher, purple martin, Oregon snowshoe hare, American badger, Southern torrent salamander, or Cascades frog because there is no suitable nesting or denning habitat within the action area for these species. Individuals and their habitat will not be impacted. The project will have no impact on the pallid bat because a Limited Operating Period (LOP) restricting work within the tunnel between April 1 and August 1 will be utilized to avoid or minimize the potential impacts to bats during the maternal roosting season. The project will have no impact on the ring-tailed cat because no potential denning structures will be removed or altered and the prescribed bald eagle LOP (January 1-August 1) will avoid or minimize the potential impacts to ring-tailed cats during the breeding season.

Archaeological Assessment

An archaeological assessment was performed by Bill Rich in Dec. 2014. Rich corresponded with 5C stating that "there is very little potential for ancestral Native American archaeological resources to be present at this location due to the intensive hydraulic mining that removed the original landform. It appears that much of the project area is well below the original historic grade. There are two archaeological sites known in the vicinity but outside of the project area" (Rich pers comm, Dec. 22 2014).

"The mining history at this spot is rather complex with several mines and different periods of mining that occurred. The project APE is occurring within this historic mining landscape. Because of extensive modern disturbance to this mining landscape, such as grading and removal of tailings, road construction, residential development, etc., I think a determination that the mine is not eligible for listing to the National Register of Historic Places is appropriate. If the area had been relatively untouched since the 1950s when the last mining occurred, or the landscape embodied some unusual or unique mining qualities, a different determination would be warranted. Pursuant to Section 106 of NHPA, the Conner Creek fish passage project therefore should have no effect to historic properties, because none are present" (Rich pers comm, Dec. 22 2014).

Bedrock and Soil Assessment

This project provided for readily observable geologic foundation and soils assessments without drilling or extensive geo-technical investigation. At the project location past mining removed a majority of topsoil exposing the underlying highly foliated Salmon Hornblende Schist bedrock (CDWR, 1979). The Salmon Hornblende Schist is an amphibolite-grade hornblende schist and gneiss which locally includes lenses of micaceous schist. The structural integrity of the bedrock was not tested as part of this analysis but it is recognized that the highly foliated schist parent materials can weather extensively. On-site observations of the waterfall and chute regions do not appear to exhibit excessive wear but static or dynamic testing may be needed to confirm structural suitability of placement of jumps within the bedrock.

Soils on-site are Xerothents which are shallow, well drained mixes of rock and material weathered from the schist parent material (NRCS, 1998). Tailing piles of cobbles and boulders are the only remaining components of the regolith in much of the project area. Smaller particles (gravels, sand, silts and clays) were washed downstream during the mining of the site, while larger materials were removed from sluice boxes and stacked. Soil erosion potential as a result of mechanical operations is minimal due to the past strip mining of the fine particle elements of the soil mantle.

Botanical Assessment

A Natural Diversity Database record check for rare plants indicated that there are six CA Native Plant Society list 1 or 2 species within the Junction City and Dedrick quadrangle map areas (approximately 6 mile radius surrounding the project). Heckner's lewisa (Lewisa cotyledon var. heckneri) is a perennial herb that flowers from May-July and is found in crevices in cliffs, rocky slopes of granite or basalt and found near streams. The project area may contain suitable habitat for this species. Tracy's Penstomen (*Penstemon tracyi*) is known from fewer than 10 occurrences in the North Fork Trinity River and other locations in the Trinity Alps. It grows in exposed rocky outcrops and barren talus slopes. While the project area lacks talus slopes there are areas of exposed schist bedrock. Both Dudley's rush (Juncus dudleyi) and Regel's rush (Juncus regelii) are riparian species that lack habitat in the project area but are recorded within 6 miles of the project. The elongate copper moss (Mielichhoferia elongate) is found in cool, humid sites, often in shade, and restricted to rock crevices and clefts in extremely acidic, metal-rich rocks. Flagella-like atractylocarpus (Campylopodiella stenocarpa), a moss that grows on tree trunks and decaying logs is a species considered rare in California but common in other states.

While the initial survey did not find any specimen of these species, a flowering season botanical survey of the project area will be completed in the spring-summer of 2015.

Landowner Considerations

In order to better understand landowner objectives, 5C staff members corresponded with two of the three landowners periodically through email and met for on-site discussions. As concepts were developed landowners provided valuable feedback. Landowners indicated that they could not support designs that would place the stream on or adjacent to neighboring parcels. This constraint eliminates the ability to relocate the channel off of their property to reduce gradient. Additionally, the landowners were not supportive of moving the stream out of the tunnel sections. This constraint means that tunnel will remain a partial velocity barrier on a range of migration flows regardless of other channel modifications[4]. The range of flows targeted for upstream improvements need not exceed the range of flows that will allow passage in the tunnel. Landowner approval will be needed before entering the final design and construction phases.

Project Alternatives

The design team created three alternatives in effort to best solve the problem the two primary barriers presented. Because the tunnel is deemed a partial barrier (and because of landowner preferences) it will not be altered. A project alternatives plan view is presented in Figure 6. The dark blue line indicates the current channel alignment, the red lines indicate barrier locations, and the green line indicates the tunnel under Quail Rd. The tan line indicates the limits of the Stewarts property. The gold line indicates a preliminary Alternative 2 alignment, and the teal line indicates an alternative 3 alignment, both of which are explained below. This figure can also be seen in higher resolution in Attachment 5.

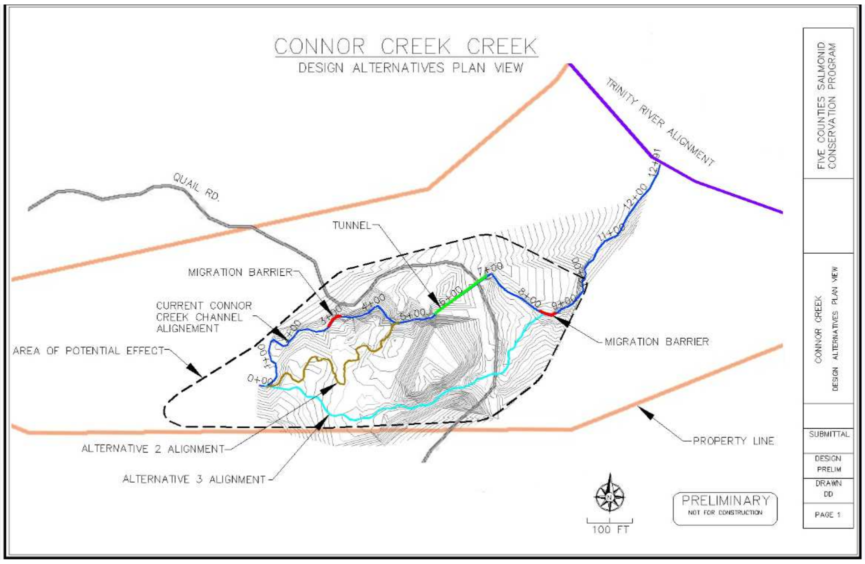

Figure 6 – Design alternatives plan view.

[4] The tunnel under Quail Rd poses less of a threat, meeting CDFW criteria 5% of the time, moderate fish ability 35% of the time, and maximum fish ability 95% of the time.

Design Alternative 1: Jump Structures

Alternative 1 consists of jump structures placed at both the waterfall and chute migration barrier within the active channel. These structures would consist of a stepped channel excavated into the existing bedrock at each barrier as seen in **Error! Reference source not found.**7 and Figure 8. This would allow fish to more successfully overcome the waterfall and chute migration barriers by creating several smaller jump stages and pools to rest in. This design does not include the creation of a new channel nor tunnel modification.

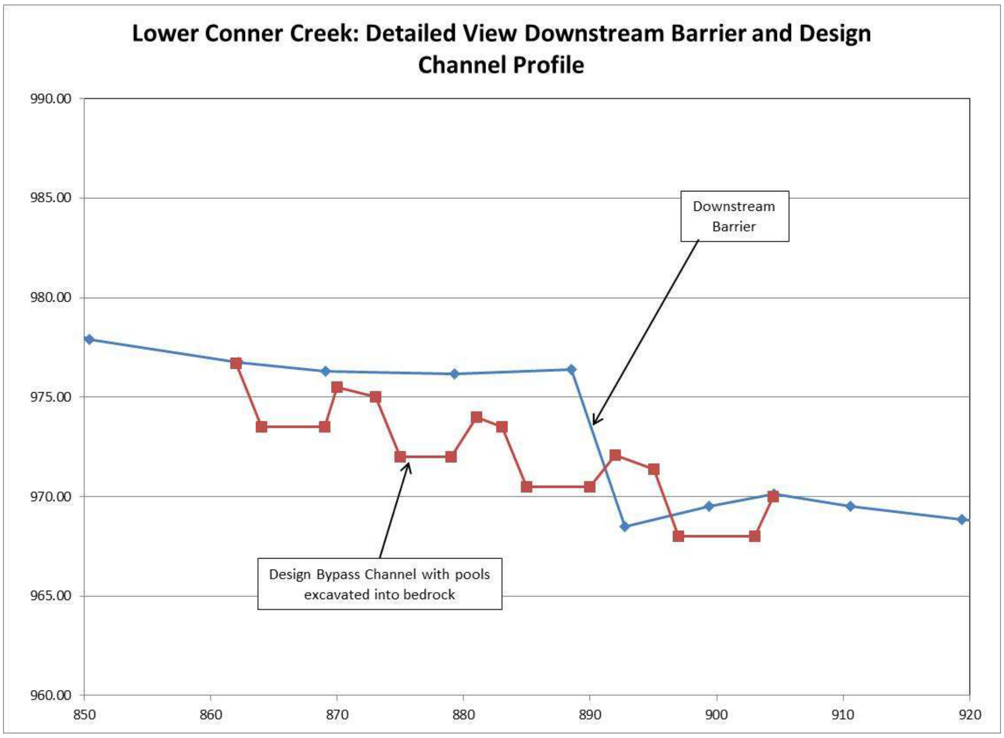

Figure 7 – Alternative 1, downstream waterfall barrier, design channel profile.

Maximum jump heights, required pool depth, distance between pools, and other jump feature measurements are described in CFDW Fish Restoration Manual and preliminary step pool measurements are provided by GMA Hydrology (Attachment 6- *Connor Creek Conceptual Alternatives*). The preliminary design spreads the downstream waterfall 6.3 ft. jump over 43 ft. (Figure 7). Individual jumps are designed to be 1.5 ft. which is consistent with natural jump heights in the stream. With jump heights of 1.5 ft., the stream would still impede juvenile passage. At the upstream chute barrier, the 8 ft. barrier would be spread out over 70 ft., with individual jumps being 1.6 ft. tall (Figure 88). The same design and construction methods would be used at both sites. Methods of failure include boulders not pooling effectively and creating barriers themselves.

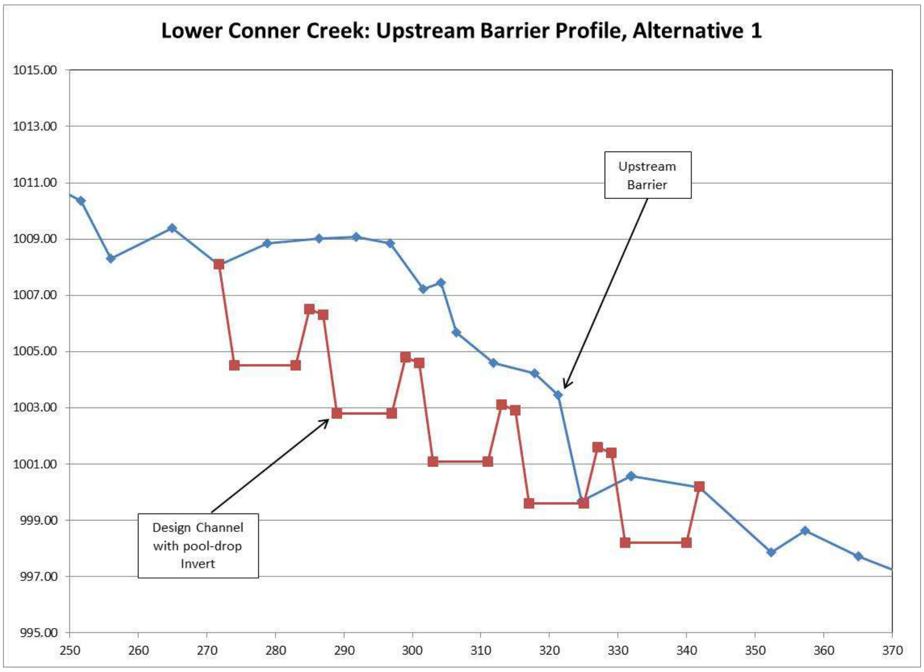

Figure 8 – Alternative 1, upstream chute barrier, design channel profile.

Boulder jump structures are technically feasible as the schist bedrock can be readily excavated to form a series of jump pools. A geotechnical investigation to determine shear and compression strengths of the bedrock will be necessary for the final design, but empirical observation of the existing stream interactions with bedrock indicated that the material may be sufficiently competent for step-pool structures. An excavator with a hydraulic jack-hammer head would be required to break the bedrock and form the jump structures. On-site survey equipment would be used to establish precise jump structure measurements. This alternative would utilize a previously constructed access road to the lower waterfall, and would require only a small area to be cleared in order to operate on the upstream chute barrier. A thorough de-watering plan would be created, indicating sump pump intakes and return locations.

Jump structures would be the most financially feasible option presented, chiefly requiring 1-2 heavy duty vehicles, jump structure materials, survey equipment, de-watering pumps and materials, and re-vegetation supplies. This alternative is estimated to take two weeks to construct.

Design Alternative 2: Partial Channel Reroute and Boulder Jump Structure

A partial channel reroute and boulder jump structure is the second alternative considered. A partial channel reroute involves creating a new channel around the upstream chute barrier at a gradient of approximately 5.1% (Figure 9). This channel would then return to the existing channel prior to the tunnel entrance. "This would also eliminate any passage issues that might arise in the slot channel upstream of the tunnel at certain flows, due to potential high velocities in that extremely confined section which has very few velocity refugia" (Matthews 2014). This alternative would utilize the same boulder jump structure at the lower waterfall as previously discussed in Alternative 1. GMA Hydrology's Alternative 2 alignment can be seen in Figure 10. This design does not include tunnel modification.

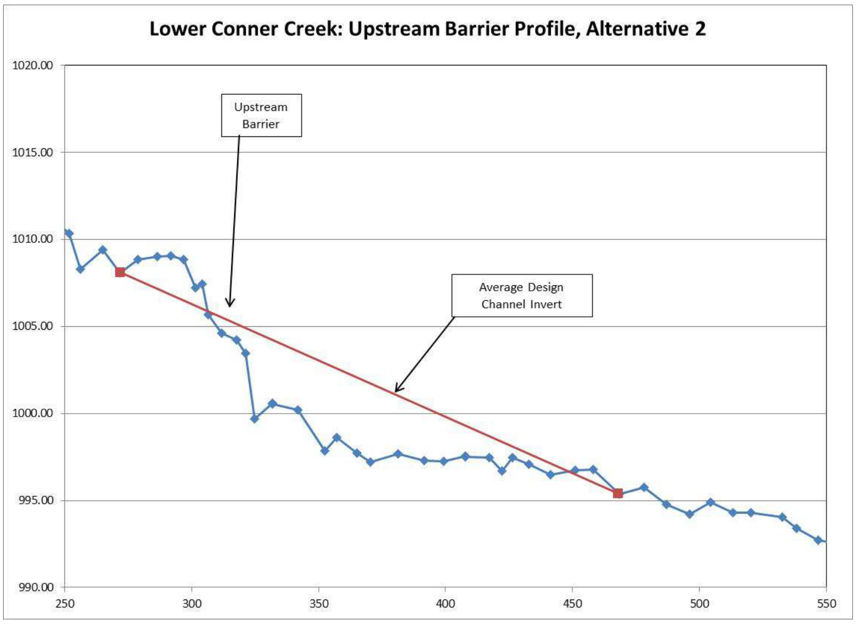

Figure 9 – Alternative 2, upstream barrier, average profile of design channel.

This option is of a similar operational feasibility as the first alternative, but with different construction constraints and risks. Instead of navigating jumps around the upstream chute barrier, fish would be required to swim at a 5.1% gradient for 255 ft. (however, rest pools and features would be implemented). Creating a new channel could allow active flow or subsurface flow to be split into either channel.

A partial channel reroute is technically feasible. It would require 3 access roads, multiple pieces of heavy equipment, and approximately 8000 cubic yards of channel excavation (Matthews 2014). Also, it would require the decommissioning of a portion of the current channel, or to leave the current channel as is without flow.

This alternative is more expensive than the previous due to the increased excavation. This project would require 2-3 heavy duty vehicles, jump structure materials, streambed material, log feature material, survey equipment, de-watering pumps and materials, and re-vegetation supplies. It would take an estimated three weeks to complete.

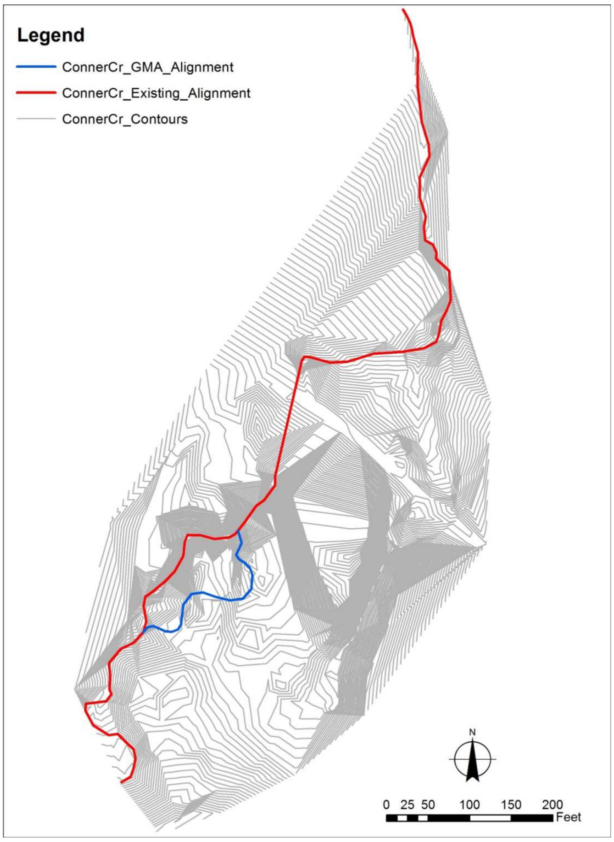

Figure 10 - Alternative 2 alignment. Existing alignment is indicated in red and the Alternative 2 alignment is indicated in blue.

Design Alternative 3: Complete Channel Reroute and Crossing Installation

This alternative would divert the channel around both migration barriers and the tunnel, and require the installation of a new bridge/culvert crossing at Quail Rd. This channel would be diverted to an existing channel path and would return near the lower waterfall barrier. This alternative would attempt to create a lower channel slope with smaller jumps to achieve this. This alternate channel alignment is indicated as the teal line in Figure 6.

Risks associated with this alternative include not being able to make a low enough grade to successfully increase fish passage, diverting to an already heavily incised channel, and the possibility of splitting flow with the addition of a new channel.

A complete channel reroute is more technically complicated. It would require 3-4 access roads, increased channel excavation and formation, culvert/bridge installation, and road closure. Also, it would require the decommissioning of a portion of the current channel and tunnel, or to leave the current channel and tunnel as is without flow. The benefit to this alternative is that would require little dewatering.

This alternative would be the most expensive. This project would require a culvert/bridge and materials, 2-3 heavy duty vehicles, jump structure materials, streambed materials, survey equipment, de-watering pumps and materials, and re-vegetation supplies. This project would take an estimated 3-4 weeks to complete.

Discussion

Of the presented design options, Alternative 1: Boulder Jump Structures is the most favorably considered. Its straightforward design with very few construction components will yield the fewest unforeseen problems and yield the highest probability of a successful fish enhancement project. By not creating a new channel (as discussed in the other alternatives), the chance of splitting surface and/or subsurface flow is mitigated. It also avoids the discussion of what to do with the old channel once flow is diverted from it. Jumps structures are also the least expensive option considered.

Design Alternative 2: Partial Channel Reroute remains a considered design alternative, primarily if boulder jump structures are deemed unfeasible to increase passage at the upstream chute. A partial channel reroute may accomplish design goals, but it has a design risk. When creating a new channel, it may be difficult to achieve a stable design slope for fish passage with a limited working area. Additionally, the risk of split surface/subsurface flow and the remnants of the chasm remain a design concern.

Design Alternative 3: Complete Channel Reroute was strongly considered, but received poor review from the landowners. Landowners were concerned by the risk of the new channel migrating to adjacent landowners' properties and receiving riparian rights. Additionally, a steep, incised channel where the reroute would occur limited appeal of the design.

Conclusion

Three migration barriers exist in Connor Creek within 1100 ft. of its confluence with the Trinity River. The primary barriers include a 6.3 ft. high waterfall and a narrow chute at 21.6% grade. Based on the fish passage assessment performed by GMA Hydrology, these barriers impede juvenile fish passage and limit adult passage during most migration flows. The chute section is a nearly complete barrier although upstream migration of steelhead has been documented. A tunnel under Quail Rd. was also analyzed as a potential barrier, but the fish passage assessment determined it would only act as a partial barrier to fish passage under very high flows.

Three design alternatives were created by the 5C design team. Alternative 1: Jump Structures involves placement of successive jump structures at the barrier sites in order to improve fish passage. Alternative 2: Partial Channel Reroute and Jump Structures includes creation of a new channel in order to reroute the existing channel around the chute barrier section. Jump structures would be installed at the waterfall barrier similarly to Alternative 1. Alternative 3: Complete Channel Reroute involves rerouting a section of Conner Creek into an adjacent channel in order to bypass both migration barriers as well as the Quail Rd. tunnel. Of the three alternatives, 5C most strongly considers Alternative 1, as it is cheaper, has a smaller footprint, and is less likely to fail than Alternatives 2 and 3. Due to landowner feedback and extended discussion between members of the 5C design team, Alternative 3 is no longer strongly considered. Based on the Wildlife Assessment performed by 5C, establishment of proper protocols and operating periods will sufficiently mitigate potential threats to at-risk species within the operating area. In addition, the archaeological assessment conducted in Dec. 2014 by archaeologist Bill Rich indicates that the project is not at risk of affecting any historically significant sites.

5C recommends pursuing the design of these alternatives. The completion of this project would significantly enhance fish access to more than 2.75 miles of upstream habitat and would build upon the completed stream simulation projects at Connor Creek Rd. and Red Hill Rd. The work performed in this feasibility study has laid the foundation of a project which could greatly impact the use of fish habitat in Connor Creek.

References

Bishop A.C., Woolley A.R. & Hamilton W.R. (1999). Cambridge Guide to Minerals, Rocks and Fossils. Cambridge University Press. p. 153. ISBN 9780521778817.

CA Department of Water Resources (1980). Trinity River Basin Main Stem Watershed Study.

CA Department of Water Resources (1979). Trinity River Basin Main Stem Watershed Study. Geologic Map

Chilcote, Samatha PhD (2014). "Connor Creek Mouth Fish Passage Enhancement Feasibility Study - Fisheries Assessment." (2014). Print.

DeJuilio, Carla. 2014. Wildlife Biological Assessment/Biological Evaluation: Conner Creek Mouth Fish Passage Enhancement Project.

Dictionary of Geology. Retrieved 2013-07-12.

Everest, Loren. 2008. Unpublished memo. Shasta-Trinity National Forest, Trinity River Management Unit Fisheries Biologist to Christine Jordan, 5C Program.

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles, 2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl., available online only at http://pubs.usgs.gov/sir/2012/5113/.Jackson J.A., Mehl J.P. & Neuendorf K.K.E. (2005). Glossary of Geology. Springer. p. 577. ISBN 9780922152766.

Matthews, Graham. "Lower Conner Creek Fish Passage Project." (2014). Print.

Matthews, Graham. "Connor Creek Fish Xing Memo." (2014). Print.

NMFS (National Marine Fisheries Service). 2008. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.

NRCS. 1998. Soil Survey of Trinity County. CA, Weaverville Area. USDA

Taylor, Ross. 2006. Excel Summary of Conner Creek Habitat Survey For Five Counties Salmonid Conservation Program. Unpublished.

List of Attachments

Attachment 1 – Connor Creek Excel

Attachment 2 – Connor Creek FishXing Memo

Attachment 3 – Connor Creek Mouth Fish Passage Enhancement Feasibility Study – Fisheries Assessment

Attachment 4 – Wildlife Biological Assessment/Biological Evaluation: Conner Creek Mouth Fish Passage Enhancement Project

Attachment 5 – Connor creek Design Alternatives Plan View

Attachment 6 – Lower Conner Creek Fish Passage Project