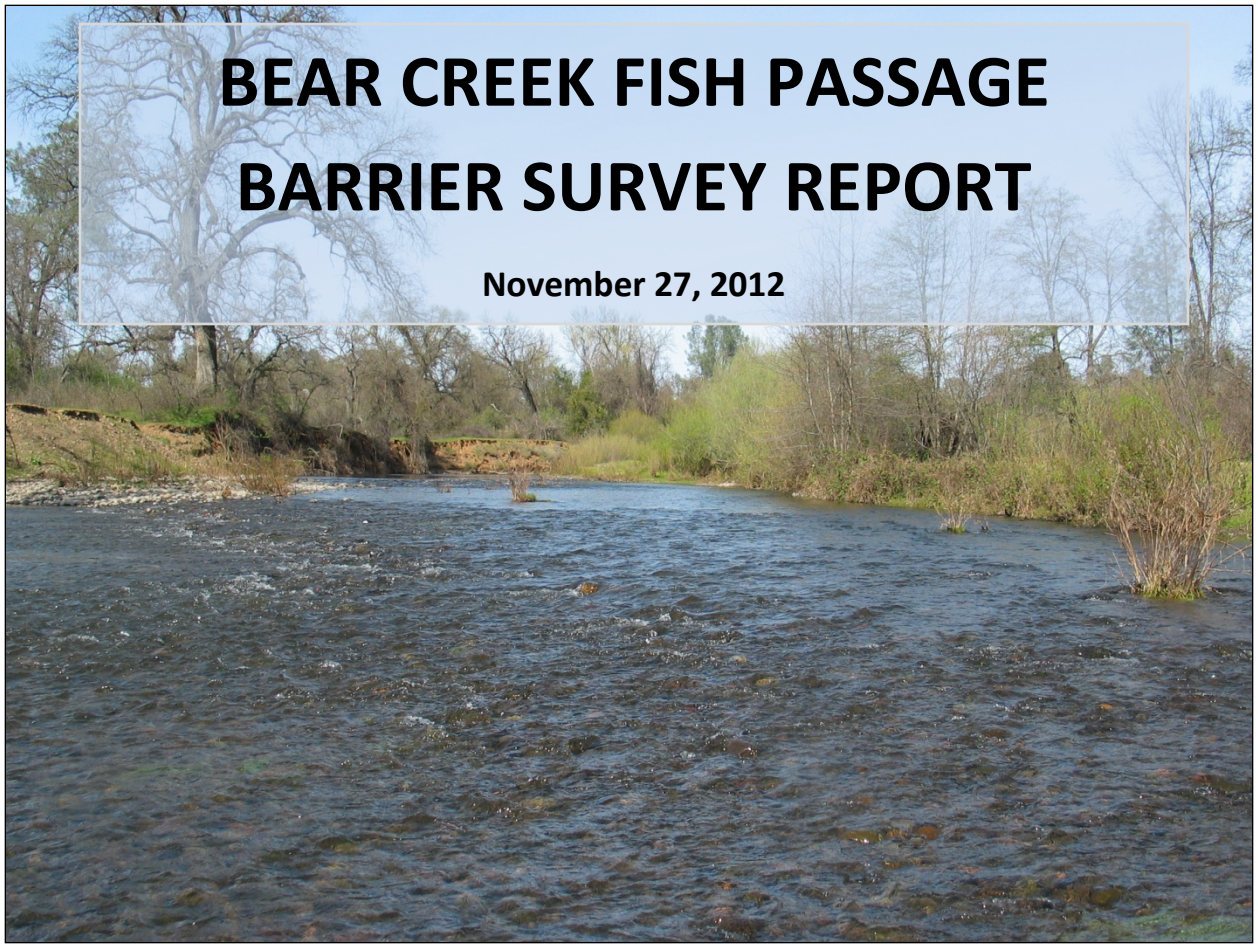
BEAR CREEK FISH PASSAGE BARRIER SURVEY REPORT

November 27, 2012



California Department of Water Resources
Fish Passage Improvement Program

Prepared by:

April McEwen, Environmental Scientist

Under the supervision of:

A. Marc Commandatore, Senior Environmental Scientist
Sara Denzler, Environmental Program Manager

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California Department of Water Resources

John Kleinfelter, James Newcomb, Trevor Greene, Kevin Marr, Megan Sheely

California Department of Fish and Game

Eda Eggeman, Patricia Bratcher, Matt Myers

Western Shasta Resource Conservation District

Leslie Bryan

Bear Creek Watershed Group

Carl Weidert, Patricia Lawrence, Warren Carlson

Cooperative Landowners

Judith Treadwell, A.J. and Clair Dumoulin, Glen and Zetti Aldridge

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Introduction

Structures such as dams, diversion weirs, road crossings, gravel mining pits, flood control channels, erosion control structures, and other in-stream structures are ubiquitous and have been identified as major barriers to fish passage throughout the United States and in California (CDWR 2005). When fish passage is not provided, anadromous fish species lose access to historical habitat (CFPFFHP 2010). Habitat loss and degradation negatively affects species abundance by limiting the quantity and quality of upstream habitat, reducing associated food sources, and reducing water quality. Upstream migration in steep gradient streams is also naturally limited by natural barriers (e.g., waterfalls) that create conditions impassable by fish at all times or under specific flow conditions. In addition, stranding of fish can occur due to low-flow conditions that cause natural morphological characteristics of a streambed (e.g., shallow riffles) to create isolated pools of water. In general, factors that determine whether a structural or natural feature is a barrier to fish passage include: in-stream flows, flow velocity, hydraulic conditions, the vertical height of the structure (or natural waterfall), residual pool depth (below the feature), fish species life history and biological characteristics including fish length, leaping and swimming capabilities (Bjornn and Reiser 1991, Lang et al. 2004, Reiser et al. 2006).

In response to regulatory mandates, regional strategies, and species recovery plans to increase habitat availability and access for declining special-status anadromous fish populations in the upper Sacramento watershed, the California Department of Water Resources' (CDWR) Fish Passage Improvement Program (FPIP) conducted fish passage barrier surveys on approximately 26 miles of Bear Creek. This project fulfills Task 2 under the Ecosystem Restoration Program (ERP) Grant Agreement (Agreement Number E1083004) with the California Department of Fish and Game (CDFG).

Site Description

Bear Creek watershed, home to approximately 3,000 human inhabitants and a tributary to the upper Sacramento River, is located in Shasta County at the northern end of California's Central Valley (Figure 1). Land use within the watershed is largely characterized by timber production in the upper watershed and cattle ranching in the mid-lower watershed (SRWP 2012). Bear Creek descends approximately 6,380 feet in elevation over 40 miles from its headwaters at Latour Butte (elevation 6,740 feet) to its mouth and confluence with the Sacramento River (elevation 360 feet). The Bear Creek watershed (10-digit Hydrologic Unit Code: 1802015404) drains approximately 123 mi^2 (78,720 acres), not including nearby Ash Creek, which drains separately to the Sacramento River. There are two main forks of Bear Creek, the North and South Fork. The South Fork has steeper gradient and a natural barrier to fish passage (Bear Creek Falls). The North Fork has more moderate gradient, and Central Valley steelhead have been observed previously in the upper North Fork and in the lower South Fork at the base of Bear Creek Falls (ENPLAN 2006).

Bear Creek does not currently have a flow monitoring station, although the United States Geological Survey (USGS) maintained a gauge and monitored discharge for eight years from 1960-1967 (USGS Gauge Number 11374100). 1960-67 show an average annual discharge of 82 ft^3/sec (cfs) (SRWP 2012). Monthly mean discharge during those eight years ranged from nine cfs in July to 191 cfs in February. In 1967, flows peaked at approximately 4,500 cfs. Although water levels may stay fairly high during wet

years, the stream reach below Highway 44 becomes almost dry in late summer and fall during years of low precipitation (CBDP 2000).

Little is known about the amount of water diverted for land use within the watershed, although the Sacramento River Watershed Program states that in the Bear Creek watershed "there are 56 appropriative water right holders that divert water for domestic use, irrigation, stock watering, power generation, and recreation" (SRWP 2012). Water may be diverted through direct diversion of the creek's surface water (in-stream pumps), local groundwater withdrawals, or interception of tributary surface flow.

The only known water right holder for power generation is the Bear Creek Hydroelectric Project (Nichols HydroPower) (FERC No 5766), owned by TKO Power, Inc. The Project is a small 3,200 watt capacity project on the South Fork of Bear Creek (USBOR 2003). Due to its small size, the Project is exempt from re-licensing but remains subject to any new conditions created by the listing of a special status species or the discovery of a special status species in the project area (Myers 2012, personal communication). The Project is non-consumptive and when in operation (Oct – June) affects streamflow on a steep gradient section of the South Fork between the diversion and the power house located above the South Fork's confluence with the main stem of Bear Creek.

The *Bear Creek Watershed Assessment* reported information related to Bear Creek's water quality and fishery resources (ENPLAN 2006). The assessment concluded state standards for water quality parameters including water temperature, dissolved oxygen, bacteria, and some heavy metals had not been met. Impaired water quality can have a major effect on the ability of a stream to provide adequate habitat for anadromous fish species spawning and early juvenile rearing, as well as disrupt migration routines. The main sources of concern include impacts from watershed development, road construction, agriculture and grazing, reduced flow from surface and groundwater diversions, timber harvesting, and removal of vegetation from prescribed fires.

Bear Creek Fishery Resources

Bear Creek supports three special status anadromous fish species (i.e., protected under the federal Endangered Species Act (ESA) and California Endangered Species Act (CESA)) including Central Valley steelhead (*Oncorhynchus mykiss*), four runs (fall, late-fall, winter, and spring) of Chinook salmon (*Oncorhynchus tshawytscha*) , and Pacific lamprey[1] (*Entosphenus tridentatus*) (ENPLAN 2006). However, only fall-run Chinook salmon and Central Valley steelhead are known to spawn in the Bear Creek watershed. Spring and winter-runs of Chinook salmon and Pacific lamprey migrate into Bear Creek from the Sacramento River for non-natal juvenile rearing. The previous information and additional information about fishery resources in the Bear Creek watershed can be found in the *Bear Creek Watershed Assessment* report (ENPLAN 2006).

[1] Pacific lamprey are not currently a listed species under the federal or California Endangered Species Act but have been targeted for conservation measures in the *Conservation Agreement for Pacific Lamprey* (USFWS 2012, Luzier et al. 2011).

In 2007-2010, the CDFG operated a video weir in Bear Creek, as well as nearby Cow and Cottonwood Creeks, to obtain information on the timing and quantity of Central Valley steelhead and fall-run Chinook salmon. Table 1 summarizes the number of individuals observed during those years.

TABLE 1. SUMMARY OF CENTRAL VALLEY STEELHEAD AND FALL-RUN CHINOOK SALMON ESCAPEMENT TO BEAR, COW, AND COTTONWOOD CREEKS IN SHASTA AND TEHAMA COUNTY, CA*

	Watershed Size (mi^2)	*Central Valley Steelhead*		*Fall-run Chinook salmon*		
		2008-09	*2009-10*	*2007*	*2008*	*2009*
Bear Creek	123	430	33	136	12	3
Cow Creek	431	14	52	2038	478	265
Cottonwood Creek	938	3	1	1214	510	1055

*Video weir was installed and operated by CDFG. Escapement data adapted from information found in Tuebert, Aschbacher, Mitchell (2011) and Grifantini et al. (2011). Grey shaded boxes are the highest number of individuals observed in any of the three creeks.

Video weirs were not installed on Bear Creek in 2010/11 and 2011/12 by the CDFG due to the effort and money required to set up the weirs (Killam, D., pers comm. 2012). However, a comparison snapshot of anadromous fish entering each creek shows that Bear Creek had a relatively significant return of Central Valley steelhead in 2008/09. This limited data suggests Bear Creek can be an important resource for ESA listed Central Valley steelhead, whose extinction risk is thought to have increased since 2005 (Williams et al. 2011). However, the extent of Bear Creek's importance or current utilization by anadromous species is not well known.

Regulatory Background

The National Marine Fisheries Service (NMFS) recognizes the important role Bear Creek has in helping ensure the long-term viability of special status anadromous species. In 2009, the NMFS listed Bear Creek as critical habitat for Central Valley steelhead (ESA/CESA status: threatened); lower Bear Creek as critical habitat for spring run Chinook (ESA/CESA status: threatened) and winter run Chinook (ESA/CESA status: endangered). Restoring and establishing available critical habitat for salmonid migration, spawning, and rearing are essential components of the NMFS recovery strategy to reverse trends towards extinction.

> *"Critical habitat for listed salmonids is comprised of physical and biological features essential to the conservation of the species including: space for the individual and population growth and for normal behavior; cover; sites for breeding, reproduction and rearing of offspring; and habitats protected from disturbance or are representative of the historical geographical and ecological distribution of the species. The primary constituent elements considered essential for the conservation of listed Central Valley salmonids are: (1) freshwater spawning sites; (2) freshwater rearing sites; (3) freshwater migration corridors; (4) estuarine areas; (5) nearshore marine areas; and (6) offshore marine areas" (NMFS 2009b, p.18-19).*

The CALFED Bay-Delta Program (CALFED) includes a programmatic element, the Ecosystem Restoration Program Plan (ERPP) that identifies several ecological management zones. Bear Creek is within the Bear Creek Ecological Management Unit (EMU) a subunit of the Northern Sacramento Valley EMU (CBDP 2000). The ERPP Final Programmatic EIS/EIR Technical Appendix summarizes the ecological importance of Bear Creek: "The individual value of Bear Creek is small, but cumulatively, the values of streams such as this can be integral and valuable in restoring ecological health to the Bay-Delta system, particularly

for the steelhead trout and fall-run Chinook salmon resources. Recent, but limited field studies, have shown that in some years lower Bear Creek can provide valuable non-natal rearing habitat for juvenile salmonids" (CBDP 2000, p. 197). Programmatic Action 2A of the ERPP recommends improving "passage and habitat conditions in Bear Creek by acquiring water rights from willing sellers, evaluating the removal of diversion dams, or providing alternative sources of water during important periods" (CBDP 2000, p.206). The Bear Creek fish passage barrier surveys are funded by Proposition 84 and address ERP Goals 1 and 3 (ERP Year 12 Annual Report, July 2011).

The Central Valley Project Improvement Act (CVPIA) created the Anadromous Fish Restoration Program (AFRP), which implements actions to improve habitat and increase abundance of anadromous fish populations (USFWS 2001). A primary goal of the CVPIA and AFRP is to double natural production of anadromous fish populations in California's Central Valley rivers on a long-term sustainable basis (Section 3406(b)(1)] of the CVPIA, USFWS 1992). Pursuant to this goal, cooperative efforts among government agencies (federal, state, local) and local communities have been made to: 1) identify factors related to reduced anadromous populations, and 2) increase the quality and quantity of critical habitat and Chinook salmon and steelhead populations throughout the Northern Sacramento River Valley EMU, including Bear Creek. The *Final Restoration Plan for the Anadromous Fish Restoration Program* lists two restoration action priorities in the Bear Creek watershed: (1) "Supplement flows with water acquired from willing sellers consistent with applicable guidelines or negotiate agreements to allow suitable passage of juvenile and adult Chinook salmon and steelhead during spring and early fall." (high priority); and (2) "Screen all diversions to protect all life history stages of anadromous fish" (medium priority) (USFWS 2001, p. 43).

Project Objectives and Methods

The FPIP task objectives and survey methods used to conduct the Clover Creek habitat assessment are discussed below.

Objectives

The following Bear Creek fish passage barrier survey objectives can be found in ERP Grant Agreement E1083004:

1. Conduct fish passage barrier surveys on approximately 20 miles of Bear Creek.
2. Create a map to designate the location of the barriers.

Methods

The methods used in meeting Objectives 1 and 2 are detailed below.

Objective 1: Conduct fish passage barrier surveys on 20 miles of Bear Creek.

The WSRCD and DWR's FPIP secured private property access for in-stream work. FPIP staff surveyed the main stem of Bear Creek from the mouth (confluence with the Sacramento River) to Bear Creek Falls on the South Fork. Surveys continued on the North Fork of Bear Creek to Ponderosa Way (Figure 1). The approximate stream distance of Bear Creek from its mouth to Ponderosa Way is 26 miles. For data

collection and reporting purposes, the surveyed portion of Bear Creek was divided into reaches moving upstream from the mouth of Bear Creek. Four reach boundaries were delineated by road crossings and included Parkville and Dersch Roads, Highway 44, and Ponderosa Way. The length of individual reaches was determined for each reach using recent orthorectified aerial imagery (Google Earth: images captured 7/27/2011) and drawing a line to follow the stream channel.

In accordance with ERP Agreement Number E1083004, Phase I surveys were conducted to determine the location, type, and physical characteristics of any man-made (structural) barriers in order to provide a preliminary determination regarding the extent that the barrier impedes fish passage. If any structural barriers were identified in Phase I surveys, staff were to complete a detailed Phase II analysis. Phase I surveys consisted of walking the creek to determine if any natural (i.e., log jams, waterfalls) or man-made (e.g., dams, structures) barriers existed. Data was collected on any possible barriers in accordance with guidelines obtained from the CDFG California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998). The *Fish Passage Incidental Field Form (First Pass Data Sheet)* (Appendix A) created by the Fish Passage Forum was used to collect Phase I information on relevant stream features including in-stream diversions/pumps and their operational status. Water depths were measured using a stadia rod. Phase I surveys were conducted on the following dates: Nov 4, 2008; May 6, 2010; May 11, 2010; Feb 9, 2011; October 18, 2011; October 28, 2011.

Since no stream gauge currently exists on Bear Creek, a regression formula was created by the U.S. Fish and Wildlife Service to predict Bear Creek flows and water temperatures (USFWS 2009). Historical flow data (1960-67), additional flow data collected in 2009, and current flow data from several nearby Sacramento River tributaries (e.g., Cow Creek, Deer Creek) were used to develop flow regression equations. The flow regression equations were used to estimate Bear Creek flows on the survey dates.

Objective 2. Create a map to designate the location of the barriers.

Base maps of the Bear Creek watershed were created with ESRI ArcGIS v. 10.1 Geographic Information System (GIS) software using spatial data layers that show: USGS 7.5 topographic maps, the USGS National Hydrography Dataset, and 2010 aerial photographs from the USDA National Agriculture Imagery Program (NAIP). Global Positioning System (GPS) units were used to record locations of waypoints that were used in creating a map to designate barrier location.

Results and Discussion

Reach descriptions, estimated flows on the dates of the barrier survey, and key observations are presented and discussed below.

Reach Descriptions

A description of each reach is useful for general information purposes. Approximate stream reach length in miles and character description is available in Table 2. Reaches are listed and photographs were taken starting at the confluence of Bear Creek and the Sacramento River moving upstream. Photographs of each reach can be found in Appendix C.

TABLE 2. BEAR CREEK REACHES, LENGTH, AND CHARACTER DESCRIPTION		
Reach #	***Reach Name***	***Character Description***
1	Sac River to Parkville Road	˜1.0 mi. Widest, lowest gradient section of Bear Creek. Riffle/pool morphological character. Substrate sand/cobble/boulder dominated.
2	Parkville Rd to Dersch Road	˜4.5 mi. Similar to Reach #1. More shoreline erosion impacts noticed in this reach. Many shallow riffles. Substrate cobble/gravel dominated.
3	Dersch Road to Hwy 44	˜5.2 mi. Channel gradient increases. Below Hwy 44, development near the stream increases. Substrate boulder/cobble/gravel dominated.
4	Hwy 44 to Ponderosa Way	˜15.4 mi. Channel gradient fluctuates but is steep and completely boulder/rapid dominated in some areas; interspersed with high quality pools.

Estimated Flows

Bear Creek flows are estimated for the survey dates and are provided in Table 3. It is interesting to note that even in the fall of a very wet year (2011), estimated Bear Creek flows only averaged 27 cfs in October. Another point of interest is the reach of Bear Creek from the Sacramento River to Parkville Road was surveyed twice, on November 4, 2008 and on May 11, 2011. The date of the survey is important because at the flows on November 4, 2008 (estimated 65 cfs), the surveyors encountered multiple shallow riffles (at 0.7 ft depth) that they noted may be impassable to adult fish at lower flows. The shallow riffles were a natural part of the streambed, indicating critical flows must cover these riffles for minimal passage requirements in the low gradient section of Bear Creek. The flows on May 11, 2011 (estimated 102 cfs) were higher and critical riffles were not encountered or noted by the surveyors as possible impediments to fish passage. However, to determine critical minimal flows, specific field investigation and real-time flow information is needed.

TABLE 3. ESTIMATED DAILY AVERAGE BEAR CREEK FLOWS ON SURVEY DATES		
Survey Date	***Bear Creek flows (cfs) ****	***Reach Surveyed***
Nov 4, 2008	**65**	Sac River to Parkville Road (#1)
March 23, 2010	58	Hwy 44 to Ponderosa Way (#4)
May 6, 2010	74	Parkville Road to Dersch Road (#2)
May 11, 2010	**102**	Sac River to Parkville Road (#1)
Feb 9, 2011	43	Dersch Road to Hwy 44 (#3)
October 18, 2011	24	Hwy 44 to Ponderosa Way (#4)
October 28, 2011	23	Hwy 44 to Ponderosa Way (#4)
*Flows estimated using regression analysis (USFWS 2009).		

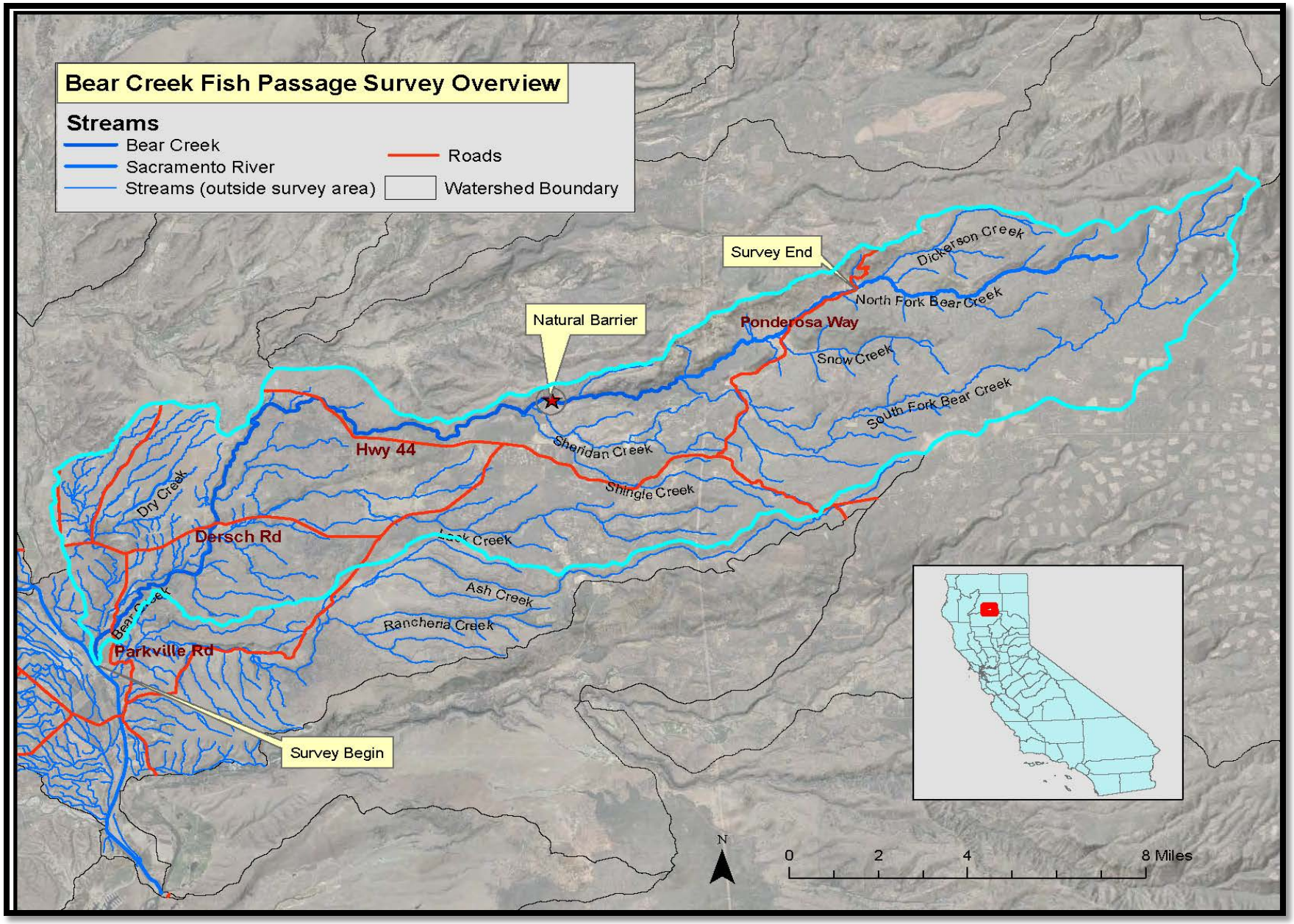

Figure 1. Bear Creek Fish Passage Barrier Survey

Key Observations and Discussion:

- No structural physical barriers to fish passage existed on the 26 mile section of Bear Creek that was surveyed. Therefore, Phase II surveys were not required (per ERP Agreement Number E1083004). One natural partial barrier, a cascade through boulders greater than a height of eight feet, was identified in the reach above Highway 44 (Figure 1; Appendix C - Photo 24). Surveys have documented adult steelhead presence above the natural partial barrier in the North Fork of Bear Creek (ENPLAN 2006). The partial natural barrier most likely only allows upstream passage during specific flow conditions. It is unlikely that fish would be able to pass upstream at all flows due to the height of the vertical drop, channel characteristics, hydraulic turbulence expected to occur given constriction, and water velocity. Fish with the highest swimming and leaping capabilities (directly related to the individual species, life stage, and size) are the most likely to be found upstream of this partial barrier. Steelhead have the greatest swimming and leaping capabilities, followed by Chinook salmon (Bell 1990).
- The other main structural features noted within the Bear Creek corridor were several small in-stream pumps. None of the pumps were operating at the time of survey and most were in non-functional condition (i.e., they had disconnected pipes or looked like they were not operable without some repair). It is unknown whether the lack of operation at pumps that were functional is temporary or long-term. It should also be noted that most of the fieldwork for this survey (Table 3) was not conducted during normal diversion periods (e.g., April – November).
- Stream bank erosion was noted throughout the stream survey. Erosion in the higher reaches of Bear Creek appeared to be mostly natural while bank erosion in the lower reaches appeared to be associated with removal of riparian vegetation and livestock access in isolated areas (see Appendix C, Photos 6 and 21). Thus, there may be opportunities for improvement of the affected areas in the lower reach (e.g., re-vegetating riparian buffers, fencing off livestock access to reduce bacterial runoff and sediment transport, other best management practices).
- Although a formal habitat assessment was not conducted and quality of habitat was not quantified, field personnel noted the overall physical quality of stream habitat (e.g., presence of gravel size substrate, riparian canopy, and habitat complexity) visually appeared to be of high quality throughout Bear Creek. However, this observation does not replace detailed habitat information that could be obtained from formal habitat mapping or provide information related to existing water quality stressors that would be provided through water quality monitoring.
- The mouth of Bear Creek has been identified previously as a possible barrier to upstream fish passage (ENPLAN 2006). On November 4th, 2008 (Bear Creek estimated flow: 65 cfs), several characteristics were identified. A gravel bar existed on either side of the stream channel, extending into the stream from both sides. Water depth measurements were taken at the deepest point in the outlet cross-section and a thalweg of 1.4 ft depth was recorded (Appendix B). Sacramento River flows that day were between 5,300 – 5,900 cfs (USGS gauge: Sacramento River at Keswick, ID 11370500). On the same date, critical riffles located upstream in Bear Creek were recorded, with several only being 0.7 ft deep (Appendix B). The *Bear Creek Watershed Assessment* states the gravel bar at the mouth of Bear Creek is exposed when Sacramento River levels are low due to periods of reduced discharge from Shasta Dam (ENPLAN 2006).

- Stream gradient increases above Dersch Road, the stream channel is more confined and narrow, and boulder constricted rapids are common. Above Dersch Road, the stream character changes from riffle/pool transitions to boulder drop (rapid)/pool transitions with riffles interspersed throughout.
- Considering the lack of structural impediments to passage encountered during the Bear Creek fish passage survey, providing adequate flows to cover critical riffles in the lower reaches of Bear Creek is likely the biggest issue related to providing access to upstream habitat and enabling juvenile salmonids to emigrate from the Bear Creek system. Minimum water depth requirements may vary depending on the size of the fish but typically adult anadromous salmonids require depths of 0.8 ft (0.24 m); resident trout and juvenile steelhead trout more than 6 inches long require depths of 0.5 ft (0.15 m); and juvenile salmonids less than 6 inches long require depths of 0.3 ft (0.1 m) for passage (CDFG 2003). Providing adequate flows during critical time periods would also assist in improving water quality such as decreasing water temperatures and increasing dissolved oxygen.

Summary, Recommendations, and Information Needs

Bear Creek was assessed for fish passage barriers from its confluence with the Sacramento River to its headwaters near Ponderosa Way (approximately 26 stream miles). No structural barriers to anadromous fish passage existed during the assessment. However, a partial natural barrier (boulder constriction with vertical drop greater than eight feet) was found upstream of Highway 44 and above Bear Creek's confluence with Sheridan Creek, approximately 17 miles from the mouth of Bear Creek. Based on its vertical height at low-flows and the hydraulic conditions expected to occur at high flows, this partial natural barrier is expected to be the upper limit of upstream migration for all special status anadromous fish species under most flow conditions. In any case, the partial natural barrier would only be passable by adult salmonids such as Central Valley steelhead and possibly Chinook salmon during unknown optimal flows. These expected limits are based on general swimming and jumping capabilities of each species (Bell 1990, Bjornn and Reiser 1991, Reiser et al. 2006) and previous observations of species distribution within Bear Creek (ENPLAN 2006).

Passage issues may be encountered during low-flow conditions in the lowest reaches of Bear Creek (below Dersch Road) at shallow riffles and at the gravel bar that has formed across the mouth of Bear Creek (Appendix B). The potential for these stream features to impede passage due to shallow water depth is flow dependent; without provision of adequate flows these features could deny fish access to the majority of Bear Creek habitat. The only structural features found in the survey were small in-stream pumps for water diversion. Many of the pumps were not in functional condition. Therefore, most water diversion at the time of the survey likely occurred from either groundwater pumping (wells) or from interception and retention of tributary runoff.

In summary, the lower 17 miles of Bear Creek are thought to be accessible by salmonids if: (1) sufficient flows are provided to cover critical riffles in the main stem of Bear Creek below Dersch Road, and (2) Sacramento River water levels are sufficient to cover the gravel bar at the mouth of Bear Creek. An

additional 9-10 miles of habitat (from the natural partial barrier to 1-2 miles above Ponderosa Way) would be available to Central Valley steelhead under optimal flow conditions that would provide upstream adult access above a series of cascades above Sheridan Creek.

Base flows should be provided in Bear Creek to allow special status anadromous species access to available habitat based on the following factors: (1) all four runs of Chinook salmon, Central Valley steelhead, and Pacific lamprey either currently utilize or have utilized the Bear Creek watershed; (2) although a formal habitat assessment has not been conducted, field personnel noted Bear Creek's physical habitat appears to be of high quality; (3) no structural barriers to fish passage are present on the naturally accessible portion of Bear Creek, eliminating costs associated with modifying existing structures to allow passage or structure removal. A stream in California with high quality habitat and no structural barriers to anadromous fish passage is rare.

Recommendations

- Install gauging stations to monitor real-time flow conditions in Bear Creek. This information is essential for future assessments, watershed planning, and adaptive management.
- Monitor mouth of Bear Creek during periods when Sacramento River discharge is below 5,000 cfs. This would help to identify Sacramento River and Bear Creek flow conditions that may limit upstream passage at the mouth of Bear Creek. This information will inform resource agency personnel, dam operators (BOR), "water users" (irrigation districts, municipal & recreational users, etc.) and other stakeholders to better determine and manage for ecological flow releases in the Sacramento River below Keswick Dam to comply with NMFS (2009a) Reasonable and Prudent Alternatives (RPA's) I.2.2.B and I.2.2.C and USFWS (2001) Restoration Actions 1, 2, and Evaluation 1[2].
- In the absence of structural barriers that would impede fish passage and deplete habitat quantity, it is recommended that in-stream flow requirements be determined that would provide upstream and downstream passage to reduce the potential for stranding and to meet the life history requirements of special status species, particularly federally listed Central Valley steelhead (known to spawn in Bear Creek). We recommend estimating base flow at shallow riffles located below Dersch Road because the majority of major tributaries have already added water, and the lower reaches are the most affected by water diversions. This information could be used to guide base flow determination at critical shallow areas to meet minimum depth requirements of each species for swimming and spawning (Bjornn and Reiser 1991, CDFG 2003). Similar fish passage flow estimations on other streams have produced results that are of significant importance to stakeholders, environmental regulators, and aquatic species (see

[2] **USFWS Restoration Action 1**: *Implement a river flow regulation plan that balances carryover storage needs with instream flow needs consistent with the 1993 BO for winter-run Chinook salmon based on runoff and storage conditions, including minimum recommended flows at Keswick and Red Bluff Diversion Dams*.
Action 2: *Implement a schedule for flow changes that avoids, to the extent controllable, dewatering redds and isolating or stranding juvenile anadromous salmonids, consistent with SWRCB Order 90-5*.
Evaluation 1: *Continue study to refine a river regulation program, consistent with SB 1086, that balances fish habitats with the flow regime and addresses temperatures, flushing flows, attraction flows, emigration, channel and riparian corridor maintenance.*

Purser 2012, SWRCB 2010, SYRTAC 1999 for examples of similar estimations). Additional information related to base flows and their benefits are provided below.

- Base flows provide minimal or optimal habitat for target aquatic species and include flows that occur outside of freshets and storm events (Peak and Ecological Flow Technical Advisory Committee 2010).
- The biological objectives of base flows include providing adequate protection of habitat for aquatic species, and upstream/downstream and mainstream/tributary connectivity (such as fish passage flows) (CVFPP 2012).
- Base flows include minimum bypass flows, which are defined by the State Water Resources Control Board as the minimum instantaneous flow rate of water that is important for managing the protection of steelhead and salmon life history needs, such as: (1) maintaining natural abundance and availability of spawning habitat; (2) minimizing unnatural adult exposure, stress, vulnerability, and delay during adult spawning migration; and (3) sustaining high quality and abundant juvenile salmonid winter rearing habitat (SWRCB 2010).
- Lack of base flows in the stream creates a scenario where the stream channel and its natural features (e.g., riffles, which are also good spawning habitat) impose a barrier upon passage in addition to depleting habitat availability and quality.
- Water temperature regression equations show water temperatures increase as flows decrease (USFWS 2009). Base and optimal flows during migration periods are needed to allow fish (especially Central Valley steelhead) to access higher elevation reaches in the watershed that contain water with lower temperatures.

- In efforts to provide additional habitat, stakeholders could also consider the impact of local diversions on smaller Bear Creek tributaries that historically have supported salmonids (e.g., Dry Creek, Lack Creek, and Snow Creek). Providing flows in these tributaries during key migration periods could increase the cumulative amount of habitat available in the Bear Creek watershed.

Information Needs

Additional information is needed to assist stakeholders in developing strategies for increasing flows. Bear Creek's fishery resource information needs are directly related to watershed hydrology, water supply, and watershed land use. This information includes but is not limited to the following:

- Quantifying the current amount of water that is diverted (including the interception and retention of water) for residential, agricultural, and power generation uses and the location and timing of those diversions.
- Information regarding existing water rights appropriations and watershed adjudication (information available from the State Water Resources Control Board).
- An assessment of the spatial and temporal extent that groundwater pumping (see Barlow and Leake 2012) and surface water diversions modify or deplete Bear Creek streamflow.
- A watershed water budget using hydroclimatological data to estimate water supply inputs and outputs. This information could be used to develop a more detailed water balance profile to allow future adaptive watershed management.

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Appendix A: Fish Passage Incidental Field Form

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Appendix B: Survey Data (Downstream of Dersch Rd)

Surveyor	JN, TG, MS	JN, TG, MS	JN, TG, MS	JN, TG, MS	JN, TG, MS	JN, TG, MS	JN, TG, MS
Date	11/4/2008	11/4/2008	11/4/2008	11/4/2008	11/4/2008	11/4/2008	11/4/2008
Time	2:20 PM	2:03 PM	1:45 PM	1:32 PM	12:30 PM	11:52 AM	11:15 AM
Agency	DWR	DWR	DWR	DWR	DWR	DWR	DWR
Stream Name	Bear Creek	Bear Creek	Bear Creek	Bear Creek	Bear Creek	Bear Creek	Bear Creek
Tributary	Sac River	Sac River	Sac River	Sac River	Sac River	Sac River	Sac River
Weather	Overcast	Overcast	Overcast	Overcast	Overcast	Overcast	Overcast
Water Condition	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Flow Condition	Cont	Cont	Cont	Cont	Cont	Cont	Cont
Bank Condition	Veg	Veg	Veg	Rip Rap	Veg	Veg	Veg
Water Temp °C	14	14	14	14	14	14	14
Ambient Temp °C	16	16	16	16	16	16	16
Structure Type	Natural	Natural	Natural	Bridge	Natural	Natural	Unknown
Description	Riffle 0.7 ft deep	Riffle 0.7 ft deep	Riffle 0.7 ft deep	Grade-Bedrock trench	Riffle 0.8 ft deep, 120 ft long	0.95 ft deep at thalweg of glide; riffle 0.7 ft deep	Gravel Bar may help backwater upstream pump.
Passage Status	n/a	n/a	n/a	Green	n/a	n/a	Temporal-flow dependent
Salmonids down?		Yes	Yes	Yes	Yes	Yes	No
Salmonids up?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Diversion	x	x	x	x	x	x	Upstream of gravel
Pump Running?	x	x	x	x	x	x	x
Pipe Size	x	x	x	x	x	x	x
Screened?	x	x	x	x	x	x	x
Latitude (y): North	40.453718	40.4497647	40.448694	40.4479794	40.440376	40.4373421	40.4357721
Longitude (x): East	-122.192166	-122.195241	-122.196212	-122.1974358	-122.204064	-122.203721	-122.203679

Appendix C: Bear Creek Photographs (by Reach; downstream to upstream)

Sac River to Parkville Rd. May 11, 2010. 102 cfs.

Photo 1. Confluence of Sacramento River (left channel) and Bear Creek (right channel)

Parkville to Dersch Rd. May 6, 2010. 74 cfs.

Photo 2 and 3. Video Weir

Photo 4. Shallow river wide riffle, at an estimated 74 cfs.

Photo 5. Shallow riffle, cutbank erosion in background

Photo 6. Shoreline disturbance: cattle paths/bank erosion/lack of riparian veg. large metal object in river 0.2 mi below Parkville Road bridge.

Photo 7. Run habitat.

Photo 8. Shallow riffle, barely covered at 74 cfs (estimated flow, doesn't consider upstream diversions.

Photo 9. Gravel recruitment potential

Photo 10. Bridges spanning Bear Creek did not create any structural barriers to passage.

Dersch Rd to Highway 44. Feb 9, 2011. 43 cfs.

Photo 11. Old structure, approximately 1,000 ft upstream of Dersch Rd.

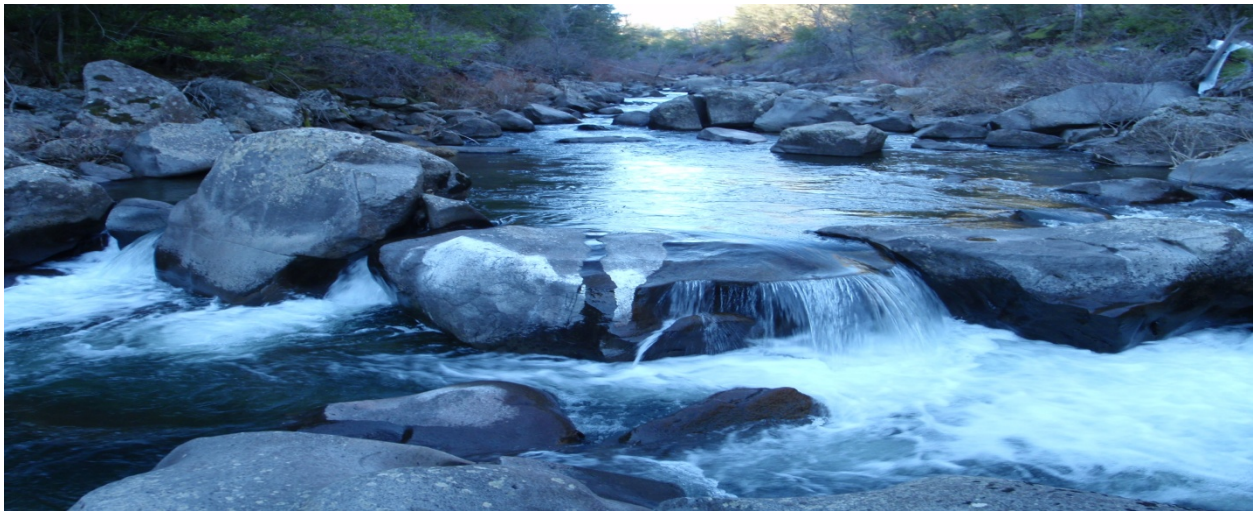

Photo 12. River gradient increases moving upstream from Dersch Rd.

Photo 13. Flow is constricted through boulder gardens increasing water velocity. While higher water levels may decrease or eliminate natural barriers to passage, conditions created by increased water velocity may hinder passage.

Photo 14. Pool-riffle habitat transition (pool tail-out) with gravel and cobble substrate

Photo 15. Typical habitat with excellent riparian vegetation shoreline coverage

Photo 16. Below bankfull stage (@42 cfs). Bankfull stage line easily visible where grass ends and stream bed begins. Road in background, some fine sediment accumulation looking upstream on river left.

Photo 17. Water diversion pipe, approximately 0.25 mi below Hwy 44 bridge, not in operation (PVC pipe leading uphill was disconnected and scattered)

Hwy 44 to Ponderosa Way


Photo 18. Side view of Bear Creek under Hwy 44 bridge.


Photo 19. Upstream of Hwy 44 bridge.

Photo 20. Typical pool-drop character

Photo 21. Natural bank erosion on steep slope

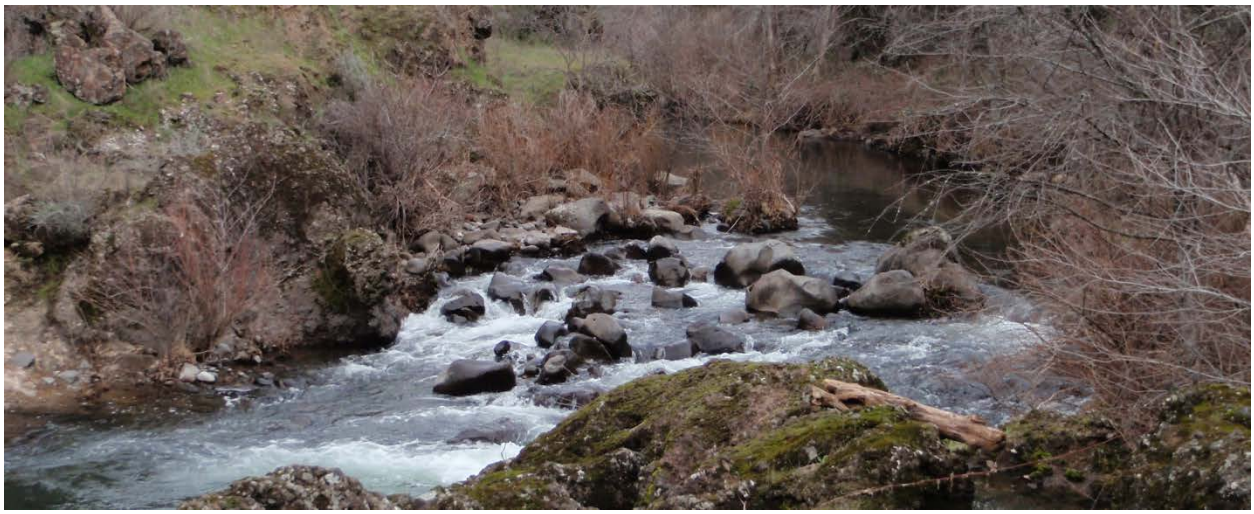

Photo 22. Typical boulder choked constriction

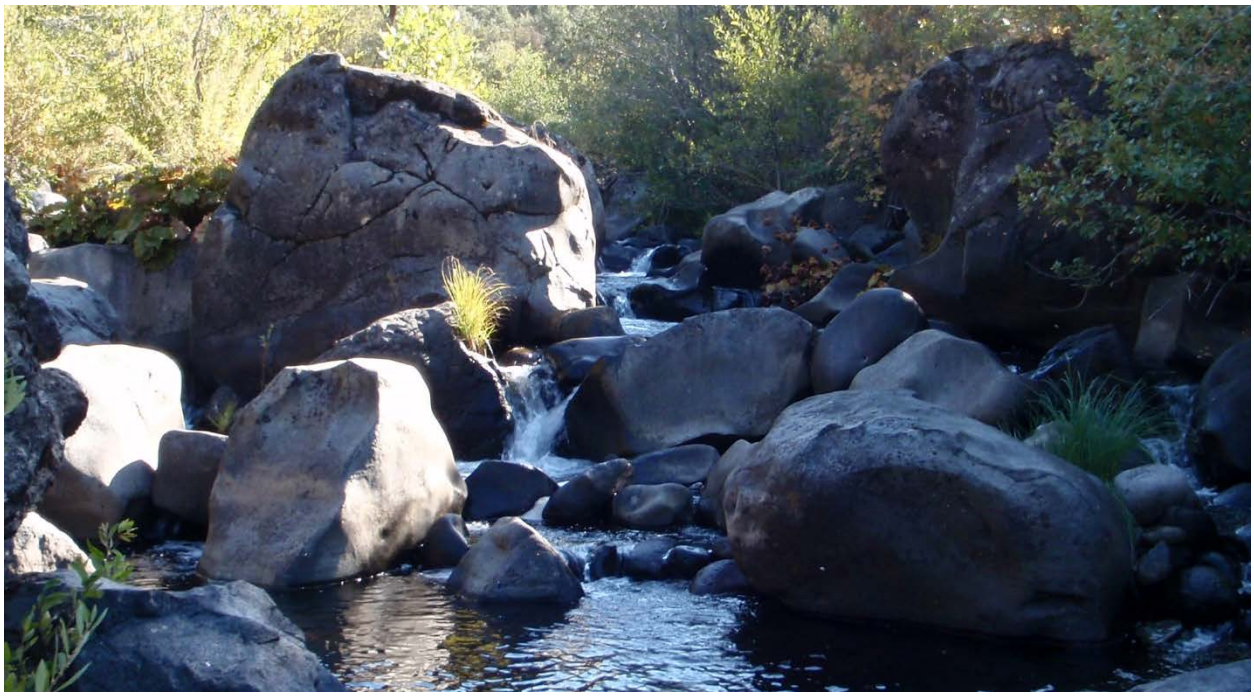

Photo 23. Flow dependent (partial) natural barrier between Elmer Rd and Hydro Plant near Inwood

Photo 24. Partial natural barrier to fish passage, greater than eight feet high, boulder garden

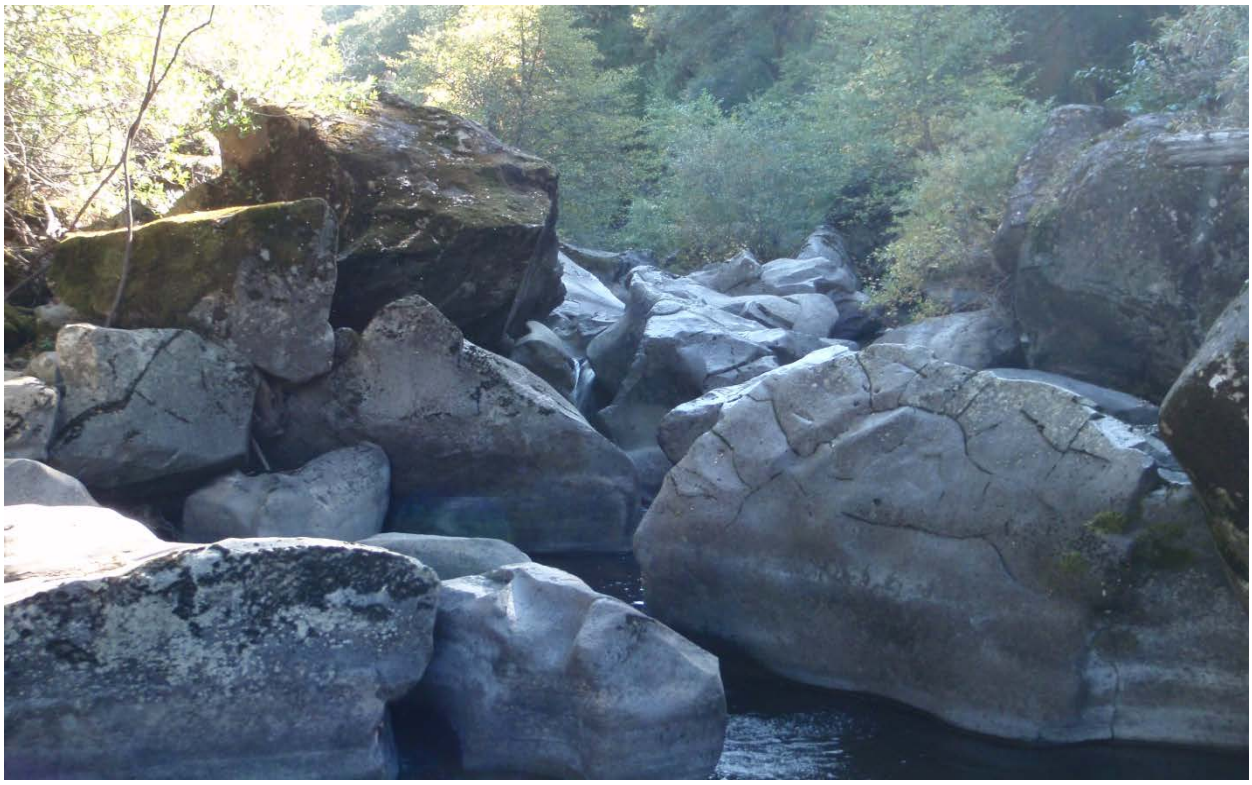

Photo 25. Boulder choked section above natural barrier (photo 24)

Bear Creek Hydroelectric Project near Inwood to Ponderosa Way

Photo 26. River narrows above the Bear Creek Hydroelectric Project, most additional water from tributaries enters downstream

Photo 27 and 28. Narrow channel fluctuates between bedrock constrained pools or runs and unconstrained vegetation dominated riffles

Photo 29. Bedrock trenches shaped out by low flows

Photo 30. Ford crossing

Photo 31. One of the last pictures taken of the reach below Ponderosa Way.