VIDEO WEIR TECHNOLOGY PILOT PROJECT
FINAL PROJECT REPORT
2008– 2010 STEELHEAD ESCAPEMENTS
COTTONWOOD, COW AND BEAR CREEKS, SHASTA AND TEHAMA COUNTY, CA

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October 2011

TABLE OF CONTENTS

TABLES AND FIGURES

TABLES

FIGURES

APPENDICES

INTRODUCTION

PURPOSE OF PILOT PROJECT

California Central Valley (CV) anadromous rainbow trout (*Oncorhynchus mykiss*) (commonly known as Steelhead) were listed as threatened under the Endangered Species Act (ESA) in 1998 (FR Vol. 63 No. 53 13347-13371 1998); threatened status was reaffirmed in 2006 (FR Vol. 71 No. 3 834-862 2006). Steelhead included in this listing consist of all naturally produced Steelhead in the Sacramento and San Joaquin rivers and their tributaries, excluding Steelhead originating from San Francisco and San Pablo Bays and their tributaries (FR Vol. 65 No. 32 7764-7787 2000, FR Vol. 70 No. 170 52488-52627 2005).

Steelhead were historically distributed throughout California's CV, with populations ranging from the Pit River in the north to the Kings River in the south (Lindley et al. 2006). Population estimates prior to European settlement are not available, but may have approached 1 to 2 million adults annually (McEwan 2001). Counts of fish migrating upstream of Red Bluff Diversion Dam from 1967 – 1991 indicate a decline from nearly 20,000 adults in 1968 to less than 1000 fish in 1991 (McEwan and Jackson 1996). Numerous anthropological impacts including the construction of impassible dams, water diversions, gravel mining, stream sedimentation, water pollution, introduction of non-native species, and the conversion of riparian zones to agricultural and urban land-uses are likely causes of these population declines (Lindley et al. 2006). Remnant Steelhead populations are presently distributed throughout the mainstem of the Sacramento and San Joaquin Rivers, as well as many of their major tributaries. Steelhead presence is highly variable in "flashy" streams and creeks in the CV and is dependent on water flow and cool temperatures, which can change drastically from year to year (McEwan and Jackson 1996). It is estimated that 80 percent of historical Steelhead spawning and rearing habitat is now located above impassible dams (Lindley et al. 2006).

The ultimate goal of the Federal Endangered Species Act is to restore populations to the point at which they no longer need protection. In general, this means demonstrating population viability (the population is no longer at risk of extinction) (McElhany et al. 2000). As these laws require demonstration of an increase in Steelhead population size, a standardized monitoring plan for Steelhead in the CV is necessary to meet these objectives.

At present, Steelhead monitoring programs in the CV lack statistical power (the ability to detect trends), are not standardized, and in many cases lack dedicated funding. Many existing monitoring programs in the CV are focused on Chinook salmon (*O. tshawytscha*) primarily because of their commercial importance. These programs are inadequate for monitoring Steelhead populations due to differences in Steelhead and Chinook life history traits (immigration timing, spawning time, spawning requirements, rearing time, rearing requirements, emigration timing, reproductive strategy, etc). For a full review and critique of existing Steelhead monitoring projects, please refer to Eilers (2008), Low (2007), and IEP Steelhead PWT (1998).

A new method for estimating Steelhead populations uses video fish weir technology, which are video cameras capturing fish movement through a fish weir. The video fish weir stations provide opportunities to easily monitor Steelhead escapement in streams that have no current monitoring programs. The video technology also includes a method to correlate daily stream temperature and flow data with Steelhead movement, providing new insight on factors affecting Steelhead escapement.

Monitoring of steelhead populations has been lacking in the tributaries of Cow, Cottonwood, and Bear Creeks. All were being monitored with video weirs to determine fall Chinook salmon population estimates. In Cow and Cottonwood Creeks, a full picture of steelhead is not available using video weir technology as a result of high turbidity during storm events and the weir structure being overtopped. Bear Creek, however, showed more promise in year-round monitoring with video weir technology.

PROJECT LOCATION

As a result of the previous success in Battle Creek, video station methodology was approved for use in other north state watersheds. A pilot project was planned for the three largest streams in the Upper Sacramento Watershed that were not being monitored: Cottonwood, Cow, and Bear Creeks. Figure 1 depicts the location of the three watersheds in relation to Redding and Red Bluff. Video fish weirs were first used to monitor steelhead in Cottonwood, Cow, and Bear Creeks in 2008.

LOCATING VIDEO STATION SITES

TO DETERMINE THE BEST LOCATION FOR THE VIDEO WEIR STATIONS, THE FOLLOWING CRITERIA WERE ESTABLISHED:

1. Limited public access to avoid vandalism and poaching opportunities.
2. A nearby power supply to run the station cameras and other electronics.
3. Sites close to the confluence of the creek with the Sacramento River so that most salmon would spawn above the site.
4. Landowner permission to construct and allow daily access to the video station.
5. Suitable stream geology to place the weir, such as a shallow, even stream bottom.

OBJECTIVES OF THE PILOT PROJECT

Main objectives of the pilot project were to:

- Obtain an estimate of Steelhead escapement into Cottonwood, Cow, and Bear Creeks.
- Collect baseline data on Steelhead escapement that can be used to evaluate restoration activities occurring in the Cottonwood, Cow, and Bear Creek watersheds.
- Further test the video weir/video data collection technology.

FUNDING

Funding for this project was provided in part by a Sport Fish Restoration Act (SFRA) Grant via the California Department of Fish and Game (CDFG) and by the Anadromous Fish Restoration Program, which is administered by the U.S. Fish and Wildlife Service (USFWS).

COOPERATORS

The three video stations were constructed and operated cooperatively by CDFG Red Bluff staff through the Sacramento River Salmon and Steelhead Assessment Project, the USFWS Red Bluff Office, the Western Shasta Resource Conservation District (WSRCD), and the Cottonwood, Cow, and Bear Creek Watershed Groups.

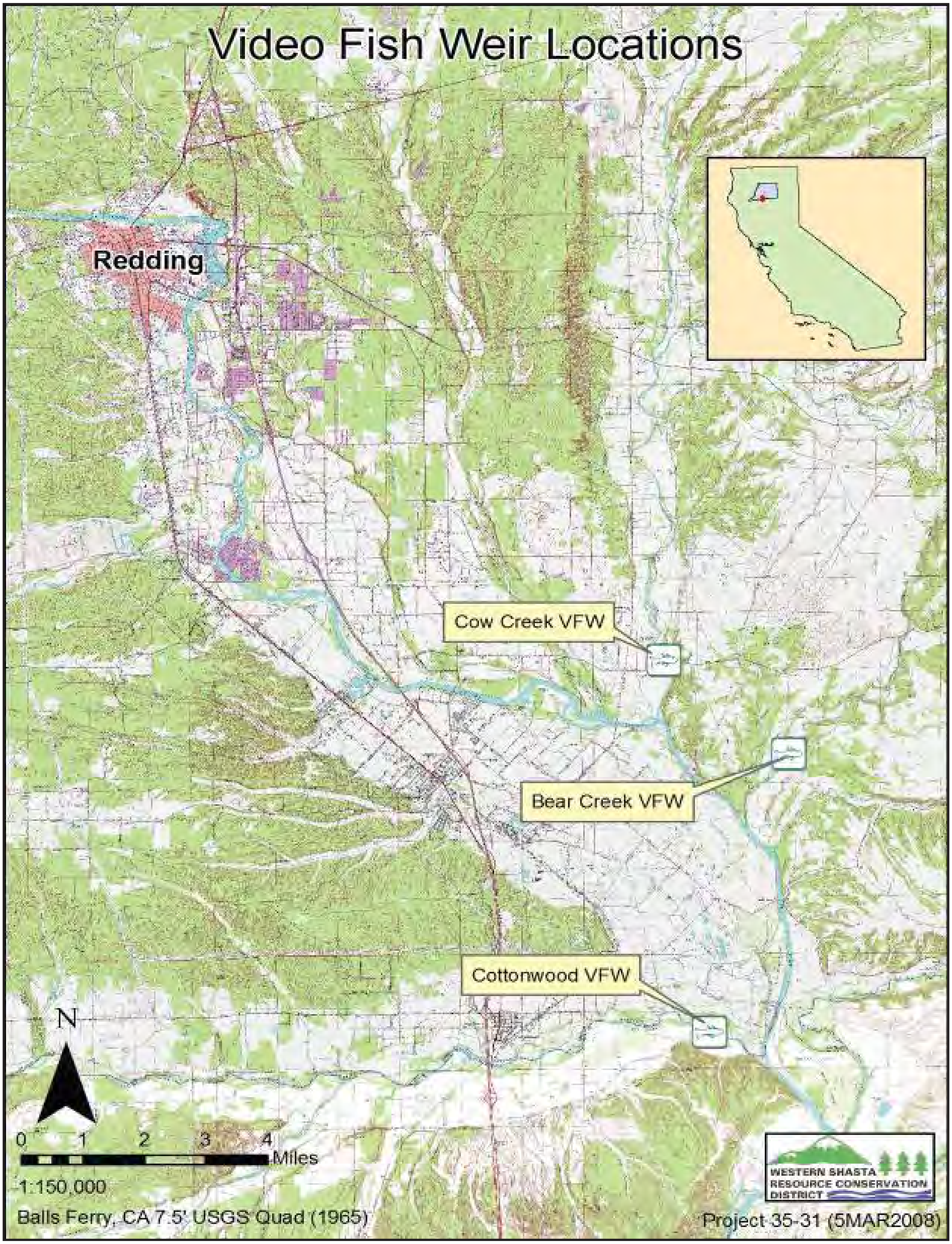

Figure 1. Video Fish Weir Project Location Map

WATERSHED FACTS AND WEIR LOCATIONS

COTTONWOOD CREEK WATERSHED FACTS

The *Cottonwood Creek Watershed Management Plan* (CH2MHILL, 2002) describes the watershed as follows:

> The Cottonwood Creek watershed lies within Shasta and Tehama counties on the northwest side of northern California's Central Valley. The lower two-thirds of the drainage area lie in Central Valley uplands, and the upstream portion includes the east slopes of the North Coast Mountain Range and Klamath Mountains and the southern slopes of the Trinity Mountains. The creek flows eastward through the valley to the Sacramento River, the confluence lying approximately 16 miles north of Red bluff and about 150 miles northwest of Sacramento. The pear-shaped watershed has three main tributaries: North Fork, Middle Fork (which flows along the Shasta-Tehama County line), and South Fork. The watershed drains approximately 938 square miles. With an annual runoff of 586,000 acre-feet, Cottonwood Creek is the third largest watershed tributary west of the Sacramento River. Cottonwood Creek is the largest undammed tributary in the upper Sacramento River basin and is a major source of sediment and gravel input to the Sacramento River.

COTTONWOOD CREEK WEIR LOCATION

The optimum location for the Cottonwood weir was ~0.5 miles upstream from the confluence with the Sacramento River in a campground located within the gated residential community of Lake California. The site had an existing 120 volt incoming power supply for the equipment (Figure 2).

COW CREEK WATERSHED FACTS

The *Cow Creek Watershed Assessment* (SHN, 2001) describes the watershed as follows:

> The Cow Creek watershed is a generally uncontrolled tributary to the Sacramento River and is located in Shasta County on the eastern side of the Sacramento River downstream of Shasta Lake. No major water storage reservoir is located on Cow Creek. Several tributaries, which include Little Cow Creek (also known as North Cow Creek), Oak Run Creek, Clover Creek, Old Cow Creek, and South Cow Creek, flow in a southwesterly direction and form the main stem of Cow Creek in Millville. The lower third of the Cow Creek watershed falls within the Great Valley Geomorphic province with the remaining area encompassing portions of the Cascade Range and Klamath Mountains provinces. The watershed encompasses approximately 430 square miles.
>
> The topography of the Cow Creek Watershed varies significantly from the flat valley areas around the main stem to the mountainous upper reaches. Elevation of the watershed varies from 340 feet above sea level at the valley floor to over 7300 feet. Annual precipitation within the watershed ranges from about 25 inches in the valley areas to about 65 inches in the northeastern mountainous portion of the watershed. Average annual flow recorded between 1950 and 1998 is 503,180 acre feet.

COW CREEK WEIR LOCATION

The optimum location for the Cow Creek video weir station was on private land ~ 0.25 miles upstream of the Dersch Road crossing over the Sacramento River (Figure 3).

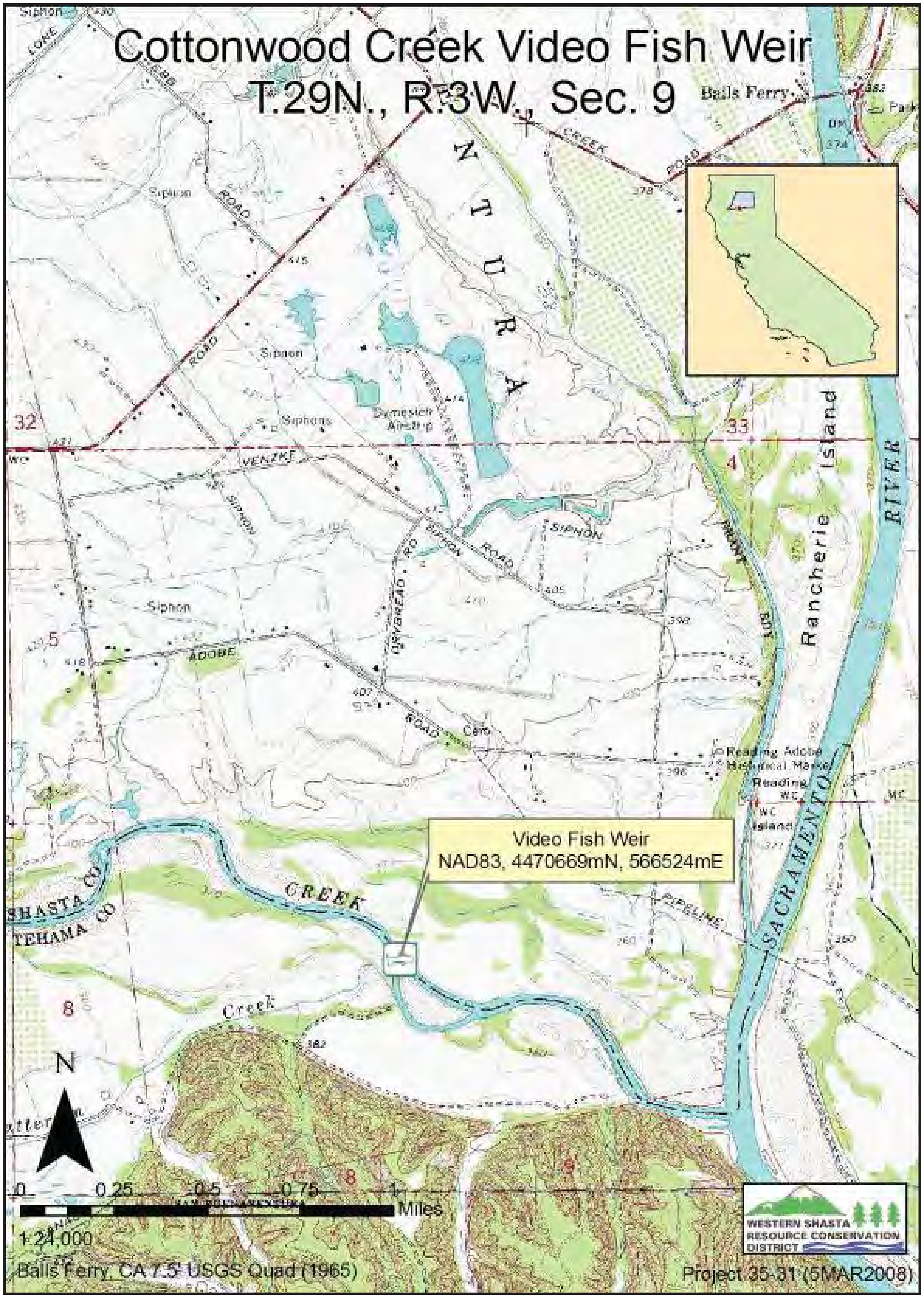

Figure 2. Map detailing the location of the video station on lower Cottonwood Creek.

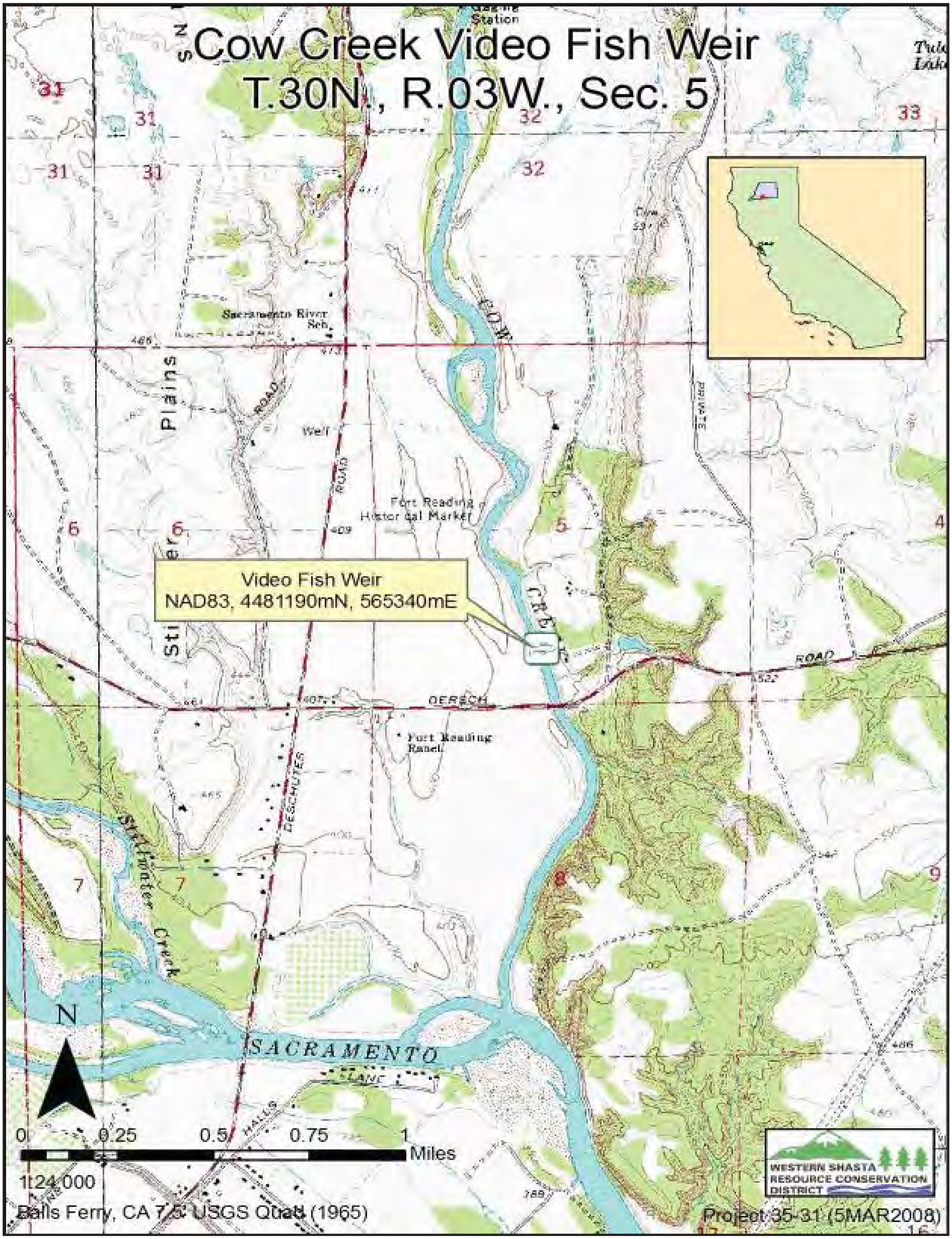

Figure 3. Map detailing the location of the Cow Creek video station.

Bear Creek Watershed Facts

The *Bear Creek Watershed Assessment* (ENPLAN, 2005) describes the watershed as follows:

> The Bear Creek Watershed lies within Shasta County at the northern end of the California's Central Valley on the east side of the Sacramento River. The watershed is located between the Cow Creek Watershed to the north and the Battle Creek Watershed to the south. The watershed encompasses portions of the Cascade Range and the Great Valley geomorphic provinces. The elevation ranges from 360 feet at its confluence with the Sacramento River, to approximately 6,740 feet in the mountains to the east. The watershed's principal tributaries are North Fork Bear Creek, and South Fork Bear Creek. The Bear Creek Watershed encompasses approximately 136 square miles. Average annual flows from 1959 – 1967 recorded in the main stem of Bear Creek at the Highway 44 Crossing was 715,312 acre feet.

Bear Creek Weir Location

The location of the Bear Creek weir was on private land upstream of the Parkville Road crossing, ~1.25 miles from the confluence with the Sacramento River.

METHODS AND MATERIALS

As a pilot project, the experimental stations progressed over the years as video and DVD recording equipment progressed. While certain equipment was originally selected as being time tested (DVR's became an invaluable tool for the project) while other equipment was used and then abandoned (VCR's, Quad Processors, certain underwater cameras, etc). New underwater cameras were valuable to help identify adipose fin clips in 2009 (hatchery fish are identifiable by removing their adipose fin when they are fry, prior to release), but these cameras were not available earlier.

Each video station was comprised of two groups of commonly available equipment:

1. Electronics:
    - Power supply and back-up power supply
    - Overhead camera
    - Underwater camera(s)
    - Lights
    - Digital video recorders (DVRs)
2. Infrastructure:
    - Weir panels
    - Camera support cables
    - DVR lock box
    - Large white plates on the stream bed

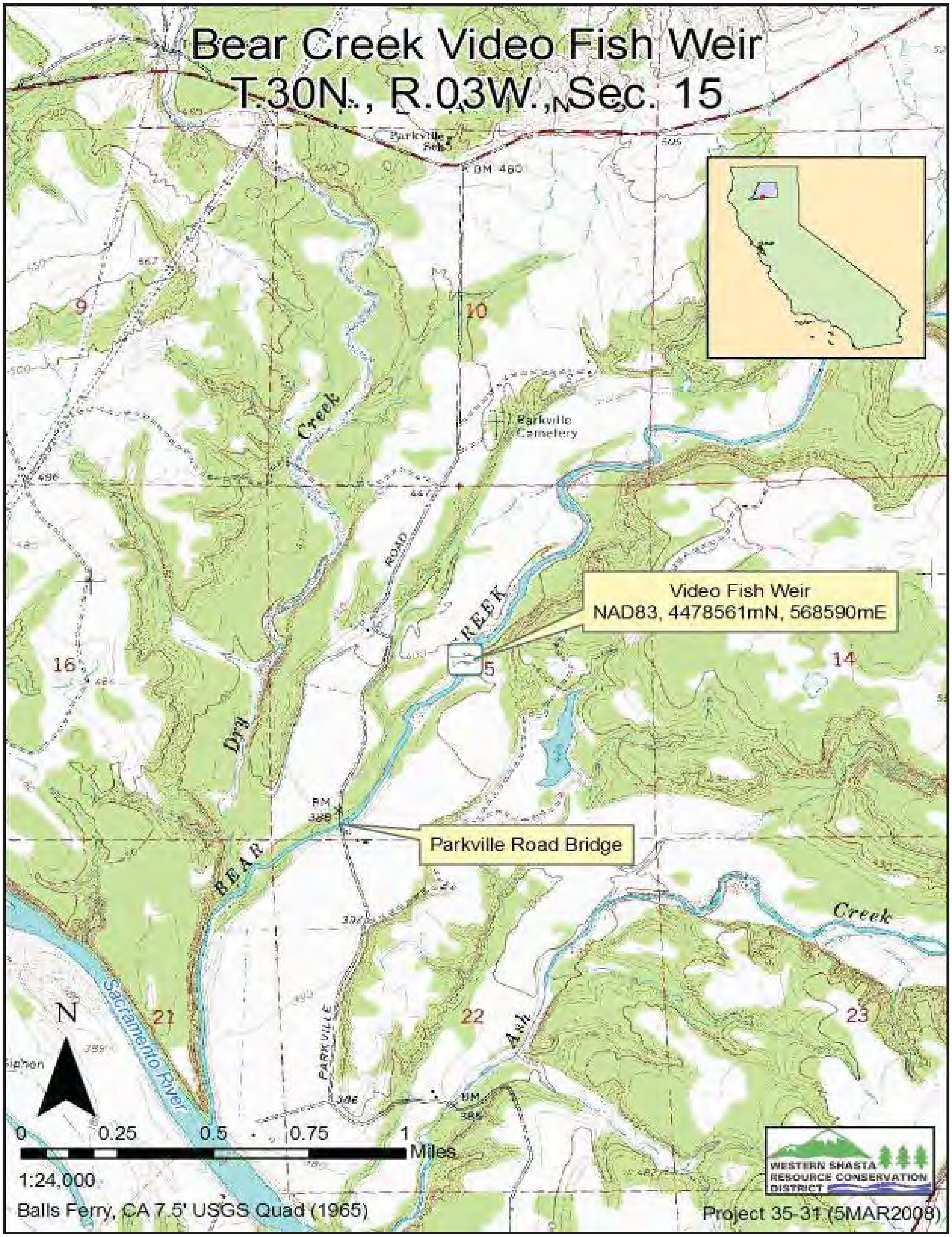

Figure 4. Map detailing the location of the video station on lower Bear Creek.

POWER SUPPLY

The three video stations were located near a conventional on-grid power supply and, if necessary, a 120-volt transformer was installed to run the camera, lights, and equipment. Wiring was run from the power supply to the cameras and recording equipment. An accessible equipment lock box was set up to keep recording equipment safe from weather and vandalism. An in-line Ground Fault Interrupt Circuit (GFIC) device provided an automatic shut-off for the system should the power supply short out or contact any water.

A back-up power supply provided power for a 1-2 day period should an outage occur in the regular power supply (consisting of 6 linked 6-volt batteries provided a 12-volt DC power supply to a conventional computer battery backup system).

OVERHEAD CAMERA SYSTEM

Weatherproof black and white cameras were chosen to provide a high quality image in various lighting conditions. The camera was attached to the outside of a larger box that contained remote lighting and other wiring hookups. The camera box was suspended from two main galvanized steel cables directly over the fish passage opening (Figures 5 and 6). The end of the main cable closest to the DVR-battery box was designed to allow easy movement up and down with a mechanical "come-along" so the camera could be raised or lowered if the lighting needed an adjustment, or if camera cleaning was required. In previous years, the system required a 10 foot ladder to clean the cameras and change the lights.

Figure 5. Bear Creek video station power supply box. Cables were used to suspend the camera directly over the weir's fish passage opening. The equipment lock box was located to the right (not shown).

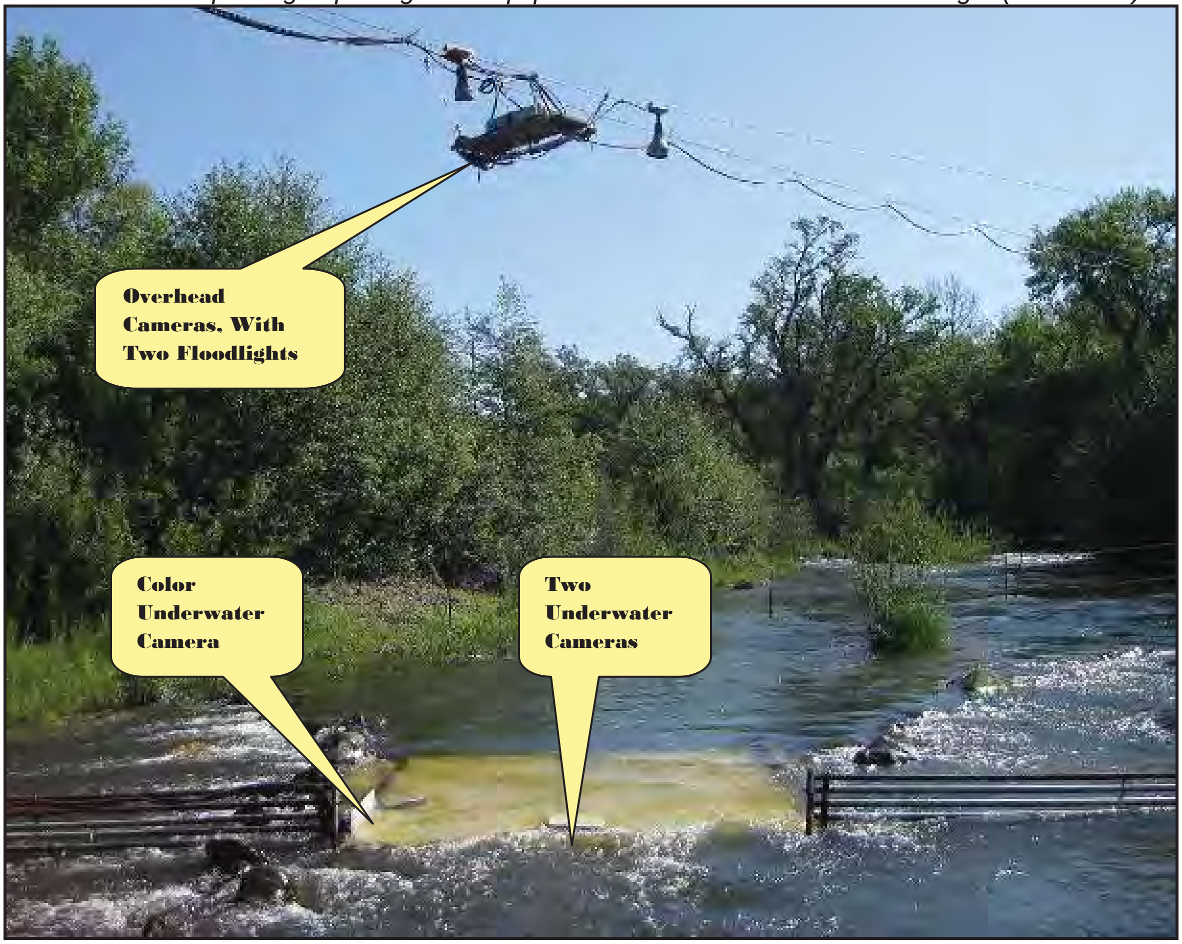

Figure 6. Camera box suspended over Bear Creek, looking upstream. Shown are three underwater cameras, the overhead camera, and the weir opening allowing fish passage.

The camera box was attached by ropes to the main cables, which reduced vibration caused by wind. Power cords and a camera co-axial cable were wired to an overhead support cable with short plastic coated utility wire and connected inside the station's DVR-battery box. Figure 7 shows the refurbished refrigerator used to secure and shelter the station's video equipment, electrical accessories and batteries.

Figure 7. The modified refrigerator contains the DVR's, power controls, equipment and storage boxes, monitor and batteries. The cable above the lock box is the anchoring cable to the two main cables suspending the camera over the creek.

UNDERWATER CAMERA SYSTEM

The underwater camera system was developed and refined over the years and became a standard tool in late 2008. In prior years, the cameras were used sporadically and were not placed in standard locations. Since late 2008, three underwater cameras were typically installed on the white weir plate (background plates). The cameras could be color or black and white, depending on the objective at the time of set-up. Two cameras were installed in the middle near the lower edge of the plate and the view set to look across the plate for a side view of passing fish. White panels were installed along the sides so the fish would be silhouetted against a light background. The third camera was installed near the top of the weir plate to one side to look across the whole weir plate (Figures 6 and 8). The underwater cameras monitored upstream and downstream movement. The use of color cameras provided an additional means of identifying fish based on distinguishing color patterns, but the best color information was available only in bright light conditions. In low light levels, such as night time, the camera merely recorded a black and white image.

The cameras were protected inside a custom-made high grade PVC water-proofed capsule. The capsule was strapped to a 20-pound metal plate that was anchored in the creek bed to withstand any pressures from the current. The camera's video and power cable ran atop the weir panels, and once away from the creek, it was buried underground from that point to the lock box to deter vandalism.

The images from the cameras were recorded on both a DVR and a backup time lapse VCR to ensure continuous video coverage in the event of a malfunction. A small TV monitor was used to observe the image from the camera and to check the DVRs for proper operation throughout the season.

Figure 8. The underwater cameras were useful for monitoring up and downstream movement as well as species identification. The two middle cameras have a sideways view.

LIGHTS

Lighting for the video cameras was provided by two compact outdoor fluorescent spotlights mounted on the overhead cable system (visible in Figure 6). A photocell sensor, similar to those used on streetlights, turned the lights on at dusk and off at dawn. Crews checked the lights for proper operation by reviewing video footage from the previous morning during their daily weir maintenance.

WEIR SYSTEM

Weirs were designed and constructed to channel salmon into the camera's view without causing passage delay (Figure 6). The weirs were constructed of 10-foot x 1 1/8 inch steel pipes welded to uprights with 3-inch spaces between the pipes. Taller panels used 1 ¼ inch EMT conduit on the inner cross-members to lighten the overall weight of the finished panel. The horizontal pipe panels were designed to fit the depth of the creek at the weir site, e.g. panels in shallow water had only two or three cross members while panels in deeper water had more. The horizontal design and spacing between bars of the weir panels allowed leaves and sticks to pass downstream while preventing salmon from passing the weir unmonitored. Panels were secured with rebar stakes and specially designed "dog leg" fittings. The rebar stakes were driven vertically through the panel uprights and into the stream bottom.

The dog leg fittings were bolted to the uprights and a “weir arm” was slid through the fitting and pounded into the stream bottom at a 45 degree angle downstream (Figure 9).

Figure 9. Construction of the weir. Dogleg fittings were bolted to the uprights and the “weir arm” slides through the fitting. This was pounded into the stream bottom at a 45 degree angle downstream.

In sandy areas or areas susceptible to undercutting, a three-foot wide chain link fence was placed down under the weir panels to prevent scour during high flows. The weir panel was situated so that six inches of the underlayment fencing protruded upstream of the weir and the remainder was exposed downstream.

Two weir panels were placed along the outside edges of the white bottom plates just above the water surface. These guidance panels at the fish passage opening prevented fish from skirting around the ends of the weir (Figure 11).

White high-density polyethylene (HDPE) sheets were staked to the creek bottom below the overhead camera to create a background to improve viewing of the passing fish (Figure 10). The sheets had ¾-inch holes drilled around the perimeters to allow staking and a metal frame plate was bolted to the upstream edge of both sheets prior to placement in the creek. Twenty-four inch concrete form stakes, with a 2-inch washer welded to the top, secured the sheets.

A metal rectangle measuring 24-inches long by 12-inches wide was attached to the sheets allowing tape readers to approximate fish lengths (Figure 11). This rectangle was also designed with a custom welded “station brand” in the center. While viewing, tape readers were able to identify individual creek footage by the brand: BR= Bear Creek (Figure 11).

Figure 10. Construction of a weir included white high density polyethylene (HDPE) sheets staked to the creek bottom to make the observation of passing salmon easier.

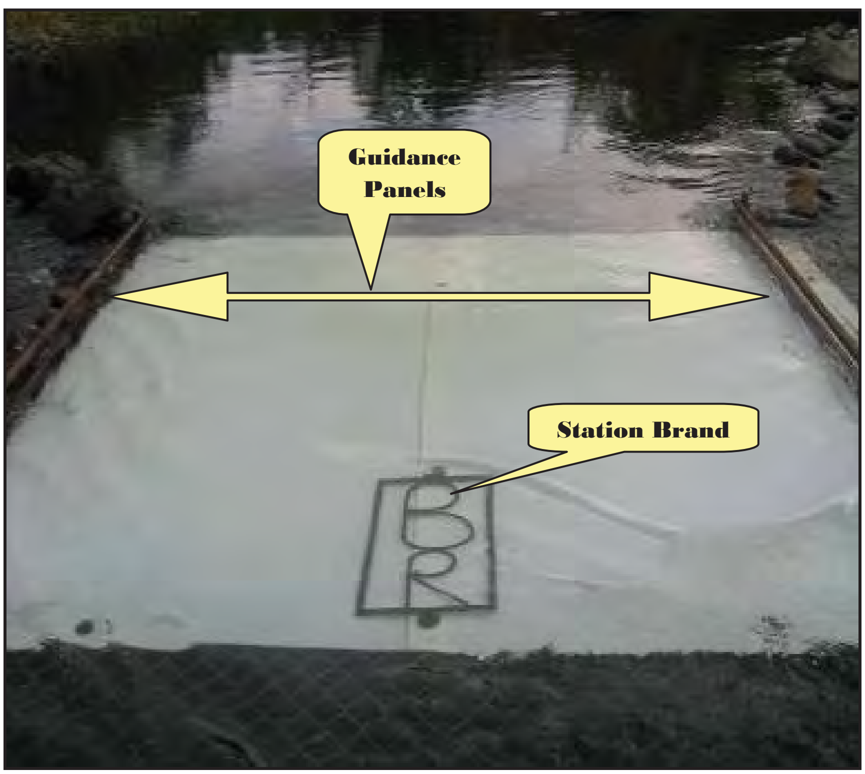

Figure 11. Two weir panels were added to the fish passage opening to prevent fish from skirting around the ends of the weir. A metal rectangle measuring 24 x 12-inches allowed tape readers to approximate fish lengths as well as identify the creek: BR= Bear Creek.

VIDEO STATION OPERATION AND MAINTENANCE

Each video station was field-checked daily during operation. Activities included:

- Checking the DVR and monitor for correct operation and camera function
- Checking power levels and normal operation of equipment (lights, DVRs, etc)
- Cleaning the weir and white plates of algae, debris, and carcasses
- Recording comments and the time of visit in the station logbook

COUNTING PROCEDURES

Each day was divided into 48 half-hour viewing periods. WSRCD and CDFG personnel reviewed DVR footage on a DVD player in the office. Any fish that passed upstream or downstream of the upper end of the white plates was counted. Fish moving downstream were subtracted from the total moving upstream for each period to maintain an accurate net upstream count. All DVRs recorded the time of fish passage, therefore, accurate determinations could be made regarding the daily timing of fish movements.

DATA ADJUSTMENTS

Several factors affected the staff's ability to count every fish that moved through the system, including:

- missing time periods due to floods (weir panels over-topped and/or turbid water),
- technical difficulties with the lights, cameras, DVD recorders, etc, or
- video reader error in species identification or actual count.

The video counts were adjusted by either adding fish or subtracting fish depending on the event that may have caused the potential discrepancy in fish tallies during that time period.

Fish counts during floods and turbid water episodes or times when technical difficulties were experienced were estimated by Doug Killam of CDFG by assessing data of actual counts of fish passage in the days before and after the event.

CDFG personnel made quality control (QC) checks on all half-hour periods where fish passage counts were greater than nine Steelhead. Any trout above 16 inches was considered a Steelhead, smolt size was 4 inches to 8 inches in size, and resident trout size was 8 inches to 16 inches. If counts for these periods were different from the original "reads," then a third count was made to determine a final count. Periods with less than 10 fish passing were stratified by the initial reader and by two types of counts: Type 0 was = 1 or less fish and Type 1 was = 2 to 9 fish. A random sub-sample of each initial reader's stratified Types of counts was reviewed for QC by Department Staff. An adjustment factor was created for each stratum (reader and Type) to adjust all type 0 and Type 1 counts (including the QC checks). The adjustment factor and original counts were multiplied (for each stratum) to determine a "final QC" count. This count was summed for each period to calculate the total Steelhead passage for the station.

QC completed datasheets were then transcribed into a Microsoft Excel file. Electronic spreadsheets were used to organize the data. Passage data was then transferred into a CDFG Microsoft Access database where it was analyzed by date, time, month and week.

Water Temperature and Flow Measurements

Water temperature data were collected using a thermograph (continuous data recorder) placed at or near each video station. Continuous water flow data for Cow and Cottonwood creeks were also compiled by accessing USGS stream gauge data on the internet (CA Data Exchange Center: **http://cdec.water.ca.gov/river/sacto-creeks1.html**). The Cow Creek gauging station is located approximately 2.0 miles upstream of the weir. The Cottonwood Creek gauging station is located approximately 1.7 miles upstream of the weir. There is no USGS gauging station on Bear Creek, however a regression equation was calculated by USFWS to estimate Bear Creek flows against Cow Creek flows using historical Bear Creek USGS data.

Steelhead Escapement Data and Analysis

Daily fish passage data in ½ -hour increments and minimum and maximum daily water temperature data were collected each year of the pilot study for all three creeks. From this data the following information could be derived:

- Seasonal summary of fish passage by day, week and month, including peak day, week and month.
- Seasonal summary of fish passage by 24 hour period in ½ -hour periods, including peak time period.

RESULTS

COTTONWOOD CREEK COMPARISON BY YEAR

The Cottonwood Creek station was monitored for Steelhead for two consecutive partial seasons starting in fall 2008. The weir was generally operational in mid September and removed in December to avoid damage from high flows. Figures 12 and 13 show fish passage compared with flow rates. The "y" axes are different on Figures 12 and 13 to allow for easier viewing of data due to the varying numbers of fish from year to year.

Cottonwood Creek 2008 Seasonal Fish Passage and Water Flow Data

The video station was operational from September 13 to December 29, 2008. The 2008 final total of Steelhead entering Cottonwood Creek was **14** for the period of the run that was surveyed. The peak day count occurred on December 25, 2008 with 4 fish passing, a mean water temperature (Appendix A) was not available for this date (the thermograph was not operational from December 7, 2008 through the end of the season on December 29, 2008), and a water flow (Appendix B) of 191 cfs. The daily fish passage data and corresponding water flow in cfs are depicted in Figure 12.

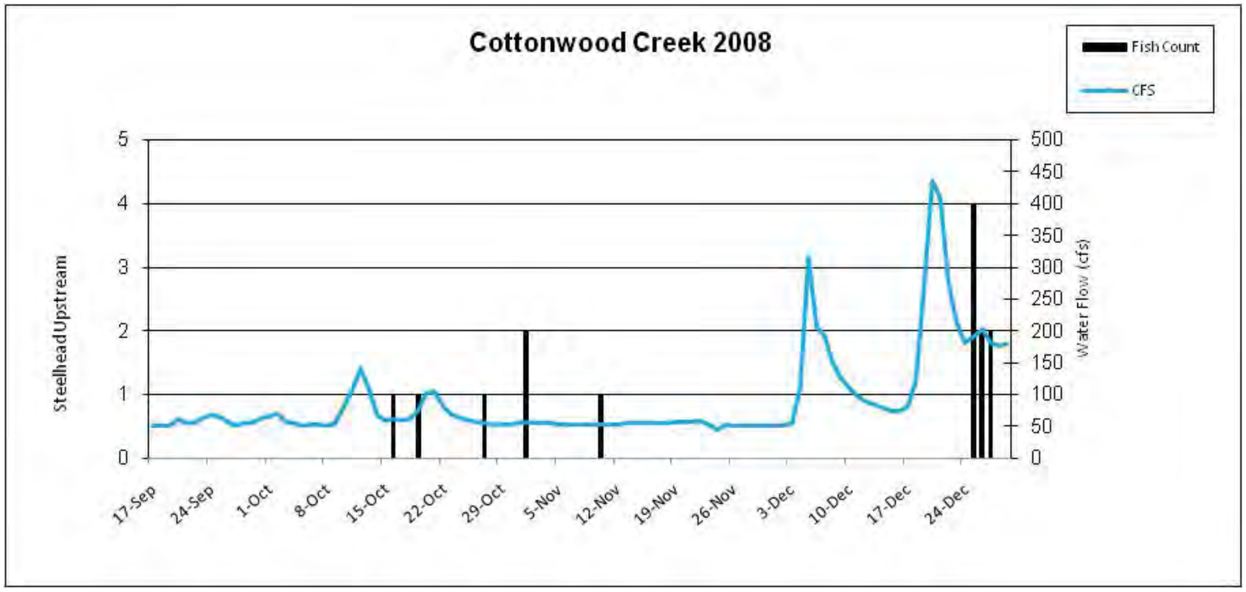

Figure 12. 2008 Total Daily Steelhead Movement vs. Water Flow (cfs); Cottonwood Creek, Shasta County

COTTONWOOD CREEK 2009 SEASONAL FISH PASSAGE AND WATER FLOW CORRELATIONS

The video station was operational from September 21 to December 21, 2009. The 2009 final total of Steelhead entering Cottonwood Creek was **52** for the period that the run was surveyed. The peak day count occurred on October 14, 2009 with 6 fish passing, a mean water temperature (Appendix A) of 63.9 (60.5-67.7°F), and a water flow (Appendix B) of 67 cfs. The daily fish passage data and corresponding water flow in cfs are depicted in Figure 13.

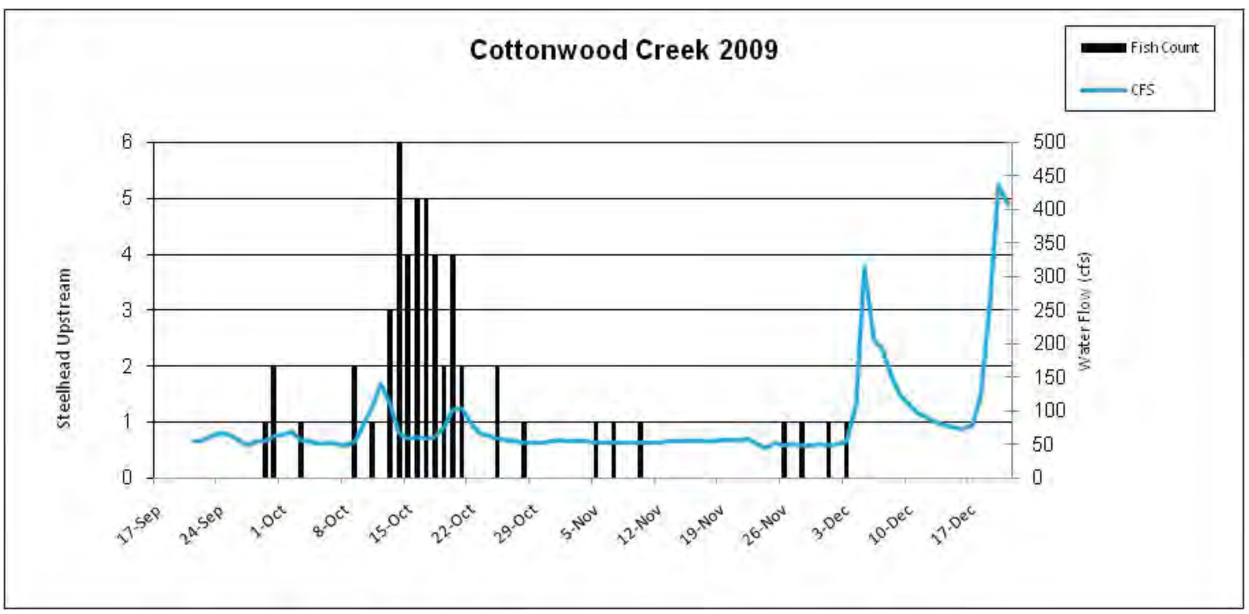

Figure 13. 2009 Total Daily Steelhead Movement vs. Water Flow (cfs); Cottonwood Creek, Shasta County

Cottonwood Creek 2008 – 2009 Fish Passage Peak Week and Month

Table 1 provides Cottonwood Creek count data by month and week for 2008 – 2009. The data reveals peak passage during the period monitored for Steelhead into Cottonwood Creek occurred in December 2008 and October 2009. Peak passage during the fall varies greatly. Data in the first and last week could be partial counts since the station was in operation only a portion of those weeks due to the timing of installation and removal of the weir. Not all the stations were installed or removed on the same day each year.

Table 1. Summary of Steelhead Passage 2008-2009, Cottonwood Creek, Shasta County, CA.

Cottonwood Creek Monthly Steelhead Summary		
	Total Fish Passage	
Month	2008	2009
September	0	3
October	3	**42**
November	3	5
December	**8**	2

Weekly Steelhead Summary			
		Total Fish Passage	
Week	Dates	2008	2009
38	Sep 17 - 23	0	0
39	Sept 24 - 30	0	3
40	Oct 1 - 7	0	1
41	Oct 8 - 14	0	12
42	Oct 15 - 21	2	**26***
43	Oct 22 - 28	1	3
44	Oct 29 - Nov 4	2	0
45	Nov 5 - 11	1	3
46	Nov 12 - 18	0	0
47	Nov 19 - 25	0	0
48	Nov 26 - Dec 2	0	3
49	Dec 3 - 9	0	1
50	Dec 10 - 16	0	0
51	Dec 17 - 23	0	0
52	Dec 24 - 30	**8***	NA
Total		**14**	**52**

*peak passage times

Cottonwood Creek 2008 – 2009 Fish Passage by Time of Day

Because the weir plate was lighted 24 hours per day, a tally of fish movement by time of day was possible as shown by Figure 14. Fish movement by time of day was similar in 2008 and 2009 with fish passage occurring in the early morning and late evening hours. Observations are limited due to the small data set available.

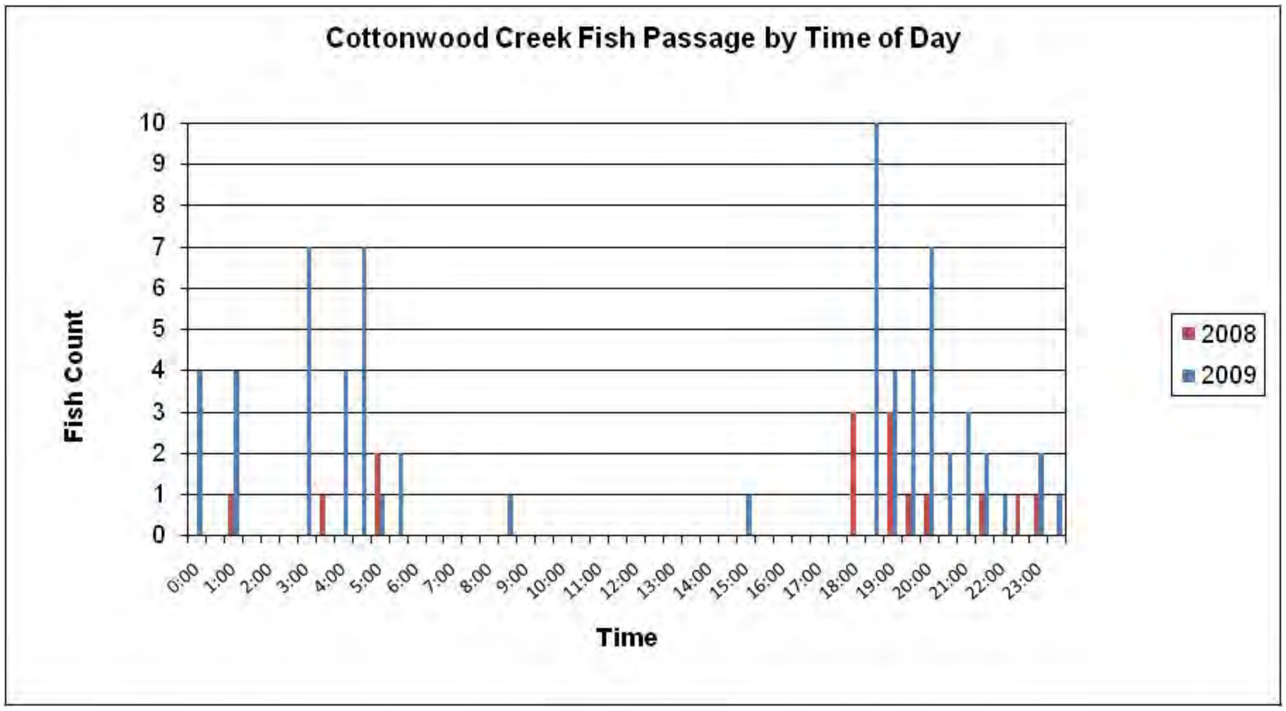

Figure 14. 2008 - 2009 Total Daily Steelhead Movement by Time Of Day; Cottonwood Creek, Shasta County

COW CREEK COMPARISON BY YEAR

The Cow Creek station was monitored for Steelhead for two consecutive partial seasons starting in fall 2008. In 2008 and 2009 the weirs generally went in during the middle of September and were taken out towards the end of December.

COW CREEK 2008 SEASONAL FISH PASSAGE AND WATER FLOW CORRELATIONS

The video station was operational between September 13 and December 18, 2008. Because the weir plate was lighted 24 hours per day, a tally of fish movement by time of day was possible. The 2008 final total of Steelhead that entered Cow Creek was **3** for the period that the run was surveyed. There was not a peak day of fish passage. The daily fish passage data, corresponding temperature (^{o}F) (Appendix A), and water flow (cfs) (Appendix B) are depicted in Table 2.

Table 2. Daily Steelhead Passage 2008, Cow Creek, Shasta County, CA.

Date	Time of Day	Fish Passage	Flow (cfs)	Temperature (^{o}F)
November 15, 2008	03:00	1	65	55
November 28, 2008	19:00	1	83	50
December 3, 2008	22:30	1	83	47

COW CREEK 2009 SEASONAL FISH PASSAGE AND WATER FLOW CORRELATIONS

The video station was operational between September 23 and December 21, 2009. Because the weir plate was lighted 24 hours per day, a tally of fish movement by time of day was possible. The 2009 final total of Steelhead that entered Cow Creek was **1** for the period that the run was surveyed. The single Steelhead passage occurred on October 26, 2009, a mean water temperature (Appendix A) of 60.3°F (57.9-66.8 °F), and a water flow (Appendix B) of 50 cfs, at 20:00.

COW CREEK 2008 – 2009 FISH PASSAGE PEAK WEEK AND MONTH

Table 3 provides count data for each month and week for the years 2008 – 2009. A total of four Steelhead were observed entering Cow Creek over two years in the months from September through December.

Table 3. Summary of Steelhead Passage 2008-2009, Cow Creek, Shasta County, CA.

Cow Creek Monthly Steelhead Summary		
	Total Fish Passage	
Month	2008	2009
September	0	0
October	0	**1**
November	**1**	0
December	**1**	0

Weekly Steelhead Summary			
		Total Fish Passage	
Week	Dates	2008	2009
38	Sep 17 - 23	0	0
39	Sept 24 - 30	0	0
40	Oct 1 - 7	0	0
41	Oct 8 - 14	0	0
42	Oct 15 - 21	0	0
43	Oct 22 - 28	0	**1**
44	Oct 29 - Nov 4	0	0
45	Nov 5 - 11	0	0
46	Nov 12 - 18	**1**	0
47	Nov 19 - 25	0	0
48	Nov 26 - Dec 2	**1**	0
49	Dec 3 - 9	**1**	0
50	Dec 10 - 16	0	0
51	Dec 17 - 23	0	0
Total		**3**	**1**

BEAR CREEK COMPARISON BY YEAR

The Bear Creek station was monitored for Steelhead for two consecutive seasons starting in fall 2008. The data presented below is representative of the 2008-2009 season and the 2009-2010 season. During these two years the weirs generally were installed in the middle of September and were removed towards the end of spring of the following year (May or June). Bear Creek did not have flow data as the other creeks in the study; however Bear Creek flows were estimated from a regression equation developed from Cow Creek flows (Appendix B). Figures 15 and 16 show water flow relative to fish passage. The “y” axes are different on Figures 15 and 16 to allow for easier viewing of data because of the varying numbers of fish from year to year.

BEAR CREEK 2008-2009 SEASONAL FISH PASSAGE AND WATER TEMPERATURE CORRELATIONS

This year the video station was maintained through Steelhead season. The video station was operational between September 33, 2008 and May 7, 2009. The 2008-2009 final total of Steelhead that entered Bear Creek was **430** for the season. The peak day count occurred on January 25, 2009 with 105 fish passing; a mean water temperature (Appendix A) was not available for this day due to a thermograph malfunction. The daily fish passage data and corresponding water flow (cfs) (Appendix B) are depicted in Figure 15.

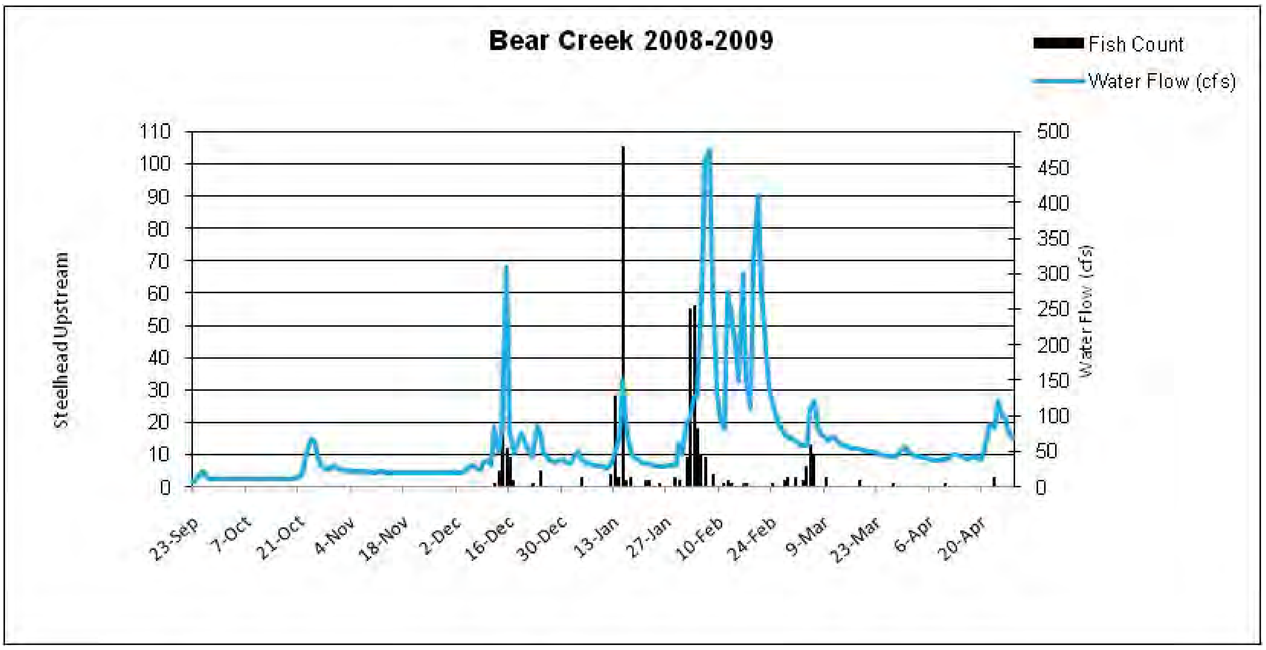

Figure 15. 2008-2009 Total Daily Steelhead Movement vs. Water Flow (cfs); Bear Creek, Shasta County.

BEAR CREEK 2009-2010 SEASONAL FISH PASSAGE AND WATER TEMPERATURE CORRELATIONS

The video station was operational between September 24, 2009 and May 26, 2010. The 2009-2010 final total of Steelhead that entered Bear Creek was **33** for the season. The peak day count occurred on February 9, 2010 with 3 fish passing and a mean water temperature (Appendix A) was 48.4^{o}F (46.9-49.8 ^{o}F). The daily fish passage data and corresponding water flow (cfs) (Appendix B) are depicted in Figure 16.

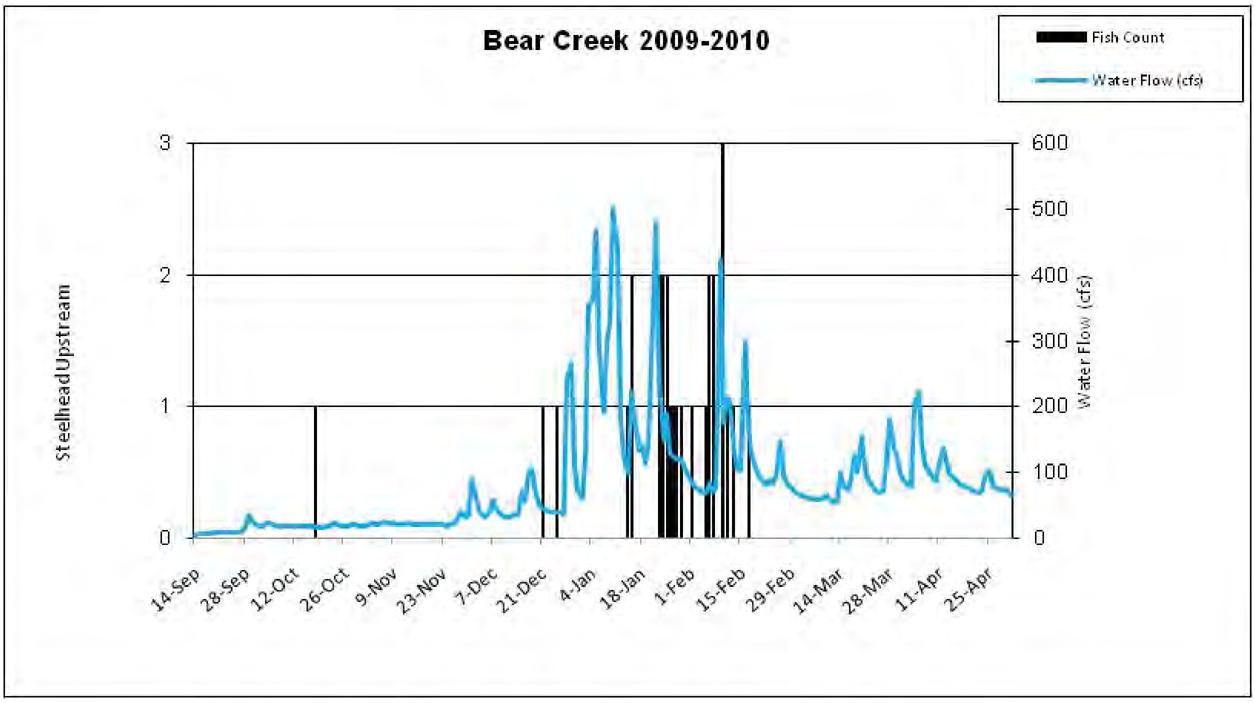

Figure 16. 2009-2010 Total Daily Steelhead Movement vs. Water Flow (cfs); Bear Creek, Shasta County.

BEAR CREEK 2008 – 2010 FISH PASSAGE PEAK WEEK AND MONTH

Table 4 provides 2008 – 2010 count data by month and week. The video station was operational into late spring in 2009 and 2010. Data reveals the peak passage for adult Steelhead at Bear Creek occurred in February 2009 and January 2010. The data in the first and last week could be partial counts since the station was in operation only a portion of those weeks due to the timing of installation and removal of the weir. Not all the stations were installed or removed on the same day each year.

Table 5 provides 2008 – 2010 total downstream smolt count data by month. Smolt counts are in addition to the total Steelhead counts presented above. Smolt passage was not documented in Cottonwood or Cow Creeks. Smolt were differentiated from adult Steelhead by size. Smolt ranged in size from 4 inches to 8 inches while adult Steelhead were 16 inches and larger. Resident trout fell into the size range of 8 inches to 16 inches.

Table 4. Summary of Steelhead Passage 2008-2010, Bear Creek, Shasta County, CA.

Bear Creek Monthly Adult Steelhead Summary		
	Total Fish Passage	
Month	2008-09	2009-10
September	0	0
October	0	1
November	0	0
December	49	2
January	156	**14**
February	**175**	11
March	45	3
April	2	2
May	3	0
June	0	NA

Weekly Adult Steelhead Summary			
		Total Fish Passage	
Week	Dates	2008-09	2009-10
38	Sep 17 - 23	0	NA
39	Sept 24 - 30	0	0
40	Oct 1 - 7	0	0
41	Oct 8 - 14	0	0
42	Oct 15 - 21	0	1
43	Oct 22 - 28	0	0
44	Oct 29 - Nov 4	0	0
45	Nov 5 - 11	0	0
46	Nov 12 - 18	0	0
47	Nov 19 - 25	0	0
48	Nov 26 - Dec 2	0	0
49	Dec 3 - 9	0	0
50	Dec 10 - 16	0	0
51	Dec 17 - 23	6	1
52	Dec 24 - 30	43	1
	January	156	**14***
	February	**175***	11
	March	45	3
	April	2	2
	May	3	0
	June	0	NA
Total		**430**	**33**

*peak passage times

Table 5. Summary of Downstream Smolt Passage 2008-2010, Bear Creek, Shasta County, CA.

Bear Creek Smolt Summary		
	Total Fish Passage	
Month	**2008-09**	**2009-10**
September	0	0
October	0	0
November	0	0
December	0	0
January	0	0
February	0	0
March	2	0
April	**239***	3
May	18	**17***
June	0	NA
Total	**259**	**20**

*peak passage times

BEAR CREEK 2008 – 2010 FISH PASSAGE BY TIME OF DAY

Because the weir plate was lighted 24 hours per day, a tally of fish movement by time of day was possible (Figure 17). Fish movement by time of day was similar in 2008 and 2009 with fish passage occurring in the early morning and late evening hours. Observations are limited due to the small data set available.

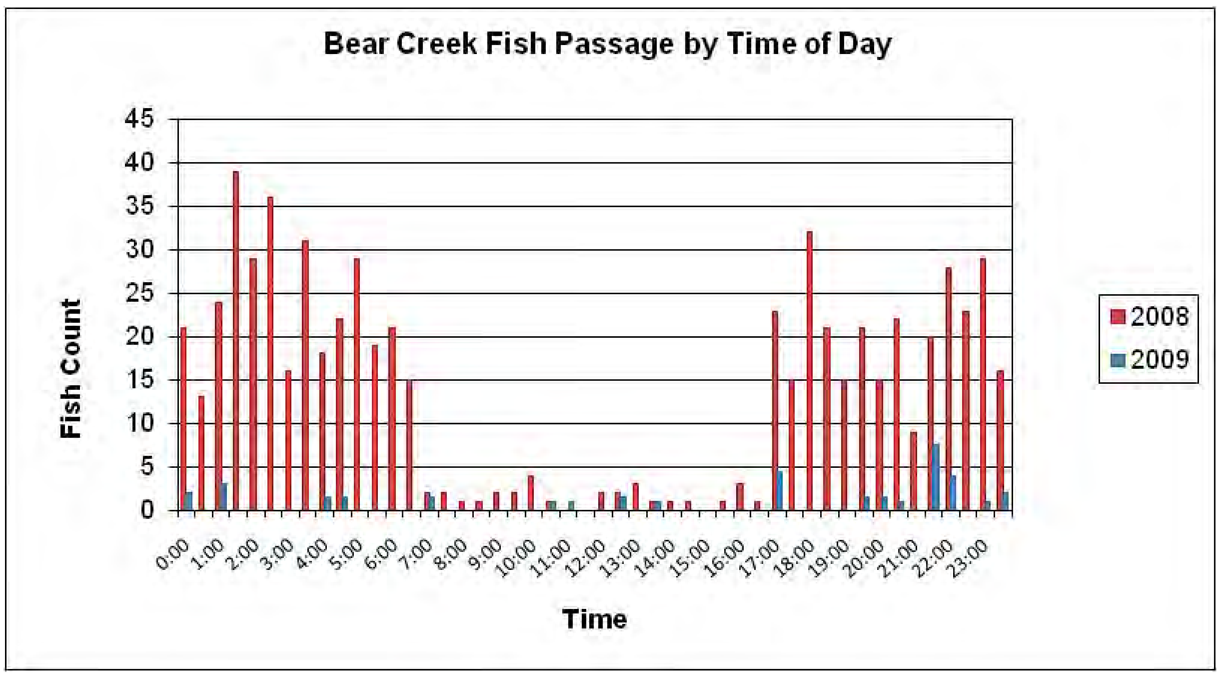

Figure 17. 2008 - 2010 Total Daily Steelhead Movement by Time Of Day; Bear Creek, Shasta County.

DISCUSSION

Tables 6 and 7 compare the times that the Bear Creek Weir was not operational by year (Appendix C). The reasons that the video weir was not operational are noted in the tables. During non-operational times, the fish counts were estimated by CDFG using recent day counts to fill in the missing periods using an average formula for days before and after when counts were verifiable. The fish weirs were not operational due to the following reasons:

- Flooding and turbid water that resulted in insufficient visibility for the counting and identification of fish.
- Video tape and camera malfunctions that resulted in no data being recorded.
- Pacific Gas and Electric (PG&E) power outage that resulted in no data being recorded.

Table 6
2008-2009 Bear Creek Weir Not Operational

Date	Percent Operational	Percent Not Operational	Reason Not Operational
9/2008-12/2009	96.3	3.7	Camera/Video Malfunction Flooding/Turbid Water
1/2009-5/2009	89.6	10.4	Camera/Video Malfunction Flooding/Turbid Water PG&E Power Outage

Table 7
2009-2010 Bear Creek Weir Not Operational

Date	Percent Operational	Percent Not Operational	Reason Not Operational
9/2009-12/2009	99.0	1.0	Lack of Water for Fish Passage Flooding/Turbid Water
1/2010-5/2010	86.7	13.3	Video Malfunction Flooding/Turbid Water

RECOMMENDATIONS

The CDFG Red Bluff Office recommends that video weir stations continue to be used as a monitoring system for Steelhead on Bear Creek. Although it is feasible to monitor fall-run Chinook salmon in Cow and Cottonwood Creeks using video weir technology, the flashy nature of these streams is not conducive to monitoring steelhead with this technology. The use of video weirs is economically feasible and accurate. CDFG plans to implement video weir stations in other creeks when funding is available. Improvements in camera, video, weir design, and power supply technology will continue to improve the video weir system, limiting the amount of time that the video weirs will be non-operational due to equipment malfunctions.

ACKNOWLEDGEMENTS

The WSRCD and the CDFG Red Bluff Office would like to thank the following:

The Lake California Property Owners Association for assisting with access to Cottonwood Creek.

Mr. Tomas Wood, Dr. Catherine Robinson, and Mr. Dale Bagley for assisting with access to Cow Creek.

Mr. Vince Shamoo and Mrs. Sandy Dubose for assistance with access to Bear Creek.

The WSRCD would like to thank Doug Killam of the CDFG Red Bluff Office, the other CDFG Red Bluff Office employees, and the Pacific States Marine Fisheries Commission employees in assisting with the fish weir installation, conducting maintenance on the fish weirs, and viewing the video data from the fish weirs.

The WSRCD and the CDFG Red Bluff Office would also like to thank the U. S. Fish and Wildlife Service, Red Bluff Office for funding to conduct these video fish weir surveys.

Special thanks to Brenda Olson, Patricia Bratcher, and Doug Killam for all their assistance in reviewing this report, valued input, and patience.

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APPENDICES

Appendix A
Temperature Data

Appendix B
Flow Data

Appendix C
Dates/Times Weirs Not Operational