Deer Creek Irrigation District
Fish Passage Improvement Project
Draft Alternative Analysis Report
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June 11, 2013

Introduction

This report summarizes DWR's cursory analysis of an alternative that allows fish passage for salmonids and Central Valley Steelhead past the Deer Creek Irrigation District (DCID) diversion dam and that meet the water demands of DCID. This report includes the following topics:

- Project Background
- Project objectives
- Design criteria and constraints
- Baseline conditions
- Summary of alternatives

Project Background

This project is funded from the Fish Passage Improvement Program (FPIP). The purpose of FPIP is to identify, plan and implement projects to remove or modify man-made barriers that impede migration and spawning of anadromous fish in the Sacramento and San Joaquin valleys.

Deer Creek is an eastside tributary to the Sacramento River located in Tehama County. Deer Creek originates on the west slope of Mount Lassen where it travels 60 miles to ultimately flow into the Sacramento River near Vina, CA. The Deer Creek watershed drains an area approximately 229 square miles.

There are three diversion dams and four screened diversion ditches in lower Deer Creek and no storage dams. Because there are no storage dams, headwater stream habitat is available for utilization by anadromous species. Except for the diversions, Deer Creek is still relatively natural and provides about 42 miles of anadromous habitat extending from the confluence with the Sacramento River upstream to Upper Deer Creek Falls. Deer Creek features unique habitat that makes it a very important resource for anadromous fish in the Sacramento Valley. Protection and maintenance of this habitat is essential to conserving anadromous stocks.

DCID is a political subdivision of the State of California, duly organized and existing under Division 11 of the California Water Code and providing water service for the irrigation of lands and crops for domestic and municipal purposes within its boundaries. DCID has a water service area of approximately 2,200 acres and delivers both surface water and groundwater to irrigate agricultural lands. Most of the irrigated lands in the water service area are in orchard production (58 percent), including almonds, walnuts and prunes, with the remainder in either pasture (37 percent) or annual grain crops (5 percent). DCID has a maximum water right of 60 cubic feet per second (cfs) but no more than 1/3 of the total flow in Deer Creek.

In some years, the upstream migration of anadromous fish may be partially impeded or blocked due to naturally occurring low flows, excessive temperatures, channel morphology, and agricultural diversions. DCID is coordinating with the California Department of Fish and Wildlife (CDFW) and DWR to implement the Deer Creek Flow Enhancement Program (DCFEP), which will aid in providing a long-term solution to fish migration issues by providing additional surface water during key migration periods. In the interim, DCID is voluntarily cooperating with CDFW by reducing agricultural diversions and providing temporary increases in fish transportation flows. In addition to the DCFEP, CDFW and DWR (jointly referred to as the State) are interested in evaluating a mutually beneficial approach to providing long-term improvements to fish passage at the DCID dam.

Project Objectives

The objective of this alternative is to identify opportunities to improve adult and juvenile fish passage over the diversion dam while meeting DCID's irrigation needs. A secondary objective includes developing a solution that requires little or no maintenance activities for public agencies or DCID. Funding to protect the natural resources and meet these objectives may be available from the public in the form of grants.

Design Criteria and Constraints

CDFW and National Marine Fisheries Service (NMFS) have fish passage and screening criteria for anadromous salmonids in this region of California. Due to the location of the diversion within the watershed, CDFW and NMFS have determined the design must meet both adult and juvenile salmonid passage criteria.

Fish Passage Criteria

The fish passage criteria are summarized in Table 1.

Table 1. Minimum and maximum fish passage criteria

Lifestage	Min Water Depth (ft)	Max Hydraulic Drop (ft)	Energy Dissipation Factor (ft-lbs/s/ft3)	Max Prolonged Swimming Speed* (ft/s)	Max Burst Swimming Speed** (ft/s)	Max Leap Speed (ft/s)
Adult	0.8	1.0	4.0	6.0	10.0	15.0
Juvenile	0.3	0.5	4.0	1.5	3.0	4.0

*Time of exhaustion is 30 minutes for both lifestages
**Time of exhaustion is 5 seconds for both lifestages

Fish Screen Structure Criteria

Fish screens shall be designed to meet the guidelines defined in Volume 1, Appendix S of the California Salmonids Stream Habitat Restoration Manual (CDFW 2004) and NMFS Southwest Region's "Fish Screening Criteria for Anadromous Salmonids" (NMFS 1997). The design criteria for on-stream screens are:

- The screen shall be designed to distribute approach velocity uniformly across the screen face.
- Approach velocities in front of screen face shall be 0.33 feet per second or less.
- Sweeping velocities shall exceed the allowable approach velocity. Sweeping velocities of 2 feet per second or greater is preferable.
- The screen structure shall consist of a cleaning mechanism to prevent flow impedance. A cleaning cycle once every 5 minutes is deemed necessary to meet this standard.
- The screen surface shall have 5/32 inches or smaller round or square opening. Slotted openings shall have a maximum of 3/32 inches width.
- The fish exposure time along the screen face shall be 60 seconds or less. The fish exposure time is the screen length divided by the sweeping velocity. Multiple bypass entrance shall be provided if the screen is long and anticipated exposure time is greater than 60 seconds.

It is the responsibility of the applicant to verify that these values are correct. Do not rely on this report for meeting regulatory criteria.

Baseline Conditions

Project Site Description

DCID diversion dam is the uppermost dam on Deer Creek. The dam is located approximately 0.5 mile downstream from the USGS gaging station along the valley floor in Tehama County (Figure 1). The dam can be identified on the United States Geological Survey, 7.5-minute series, Acorn Hollow quadrangle.

Figure 1. Deer Creek Irrigation Dam and Diversion (March 11, 2005)

The dam is a flashboard dam about 75-feet long and 2.5-feet high without flashboards. The flashboards are placed in the dam during irrigation season as early as February and remain in place through October. The flashboards consist of 2x6 boards cut in approximate 4.5-foot lengths and can be stacked 5 boards high. Currently, an approximate 8-foot center section of the dam is left open without flashboards for fish passage (Figure 2).

Figure 2. DCID dam without flashboards in the center section for fish passage (July 8, 2005, Deer Creek Flow = 135 cfs, DCID diverting 24 cfs).

Diversion Water Right

DCID has a maximum water right of 60 cfs but no more than 1/3 of the total flow in Deer Creek. Water is diverted from the left bank on the upstream side of the dam. Water enters the diversion ditch through a 10-foot wide weir section (Figure 3) and is controlled by two 48-inch wide vertical slide gates 3-feet tall (Figure 4).

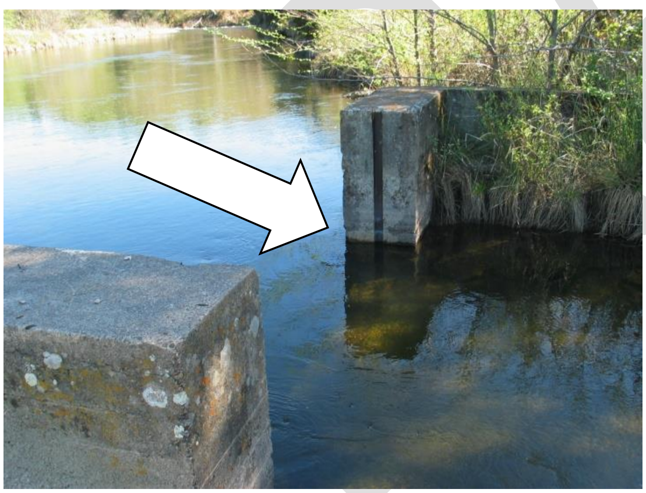

Figure 3. Diversion Ditch Weir Entrance (March 11, 2005)

Figure 4. Headwall with two 48-inch vertical slide gates (March 11, 2005)

Downstream of the slide gates is a flat plate fish screen with a juvenile bypass return (Figure 5). The juveniles are return to the creek through a pipe. The first diversion point is approximately 3.5 miles downstream of the fish screen. The diversion ditch is an earthen channel.

Figure 5. Fish screen structure (March 11, 2005).

Since 1988, diverted water has been measured and recorded using a 6-foot Parshall flume (Figure 6) located approximately 0.2 miles downstream in the diversion ditch. The mean daily diversion rate and percent of flow diverted from Deer Creek is shown in Figure 7.

Figure 6. Parshall flume on Deer Creek (May 11, 1999)

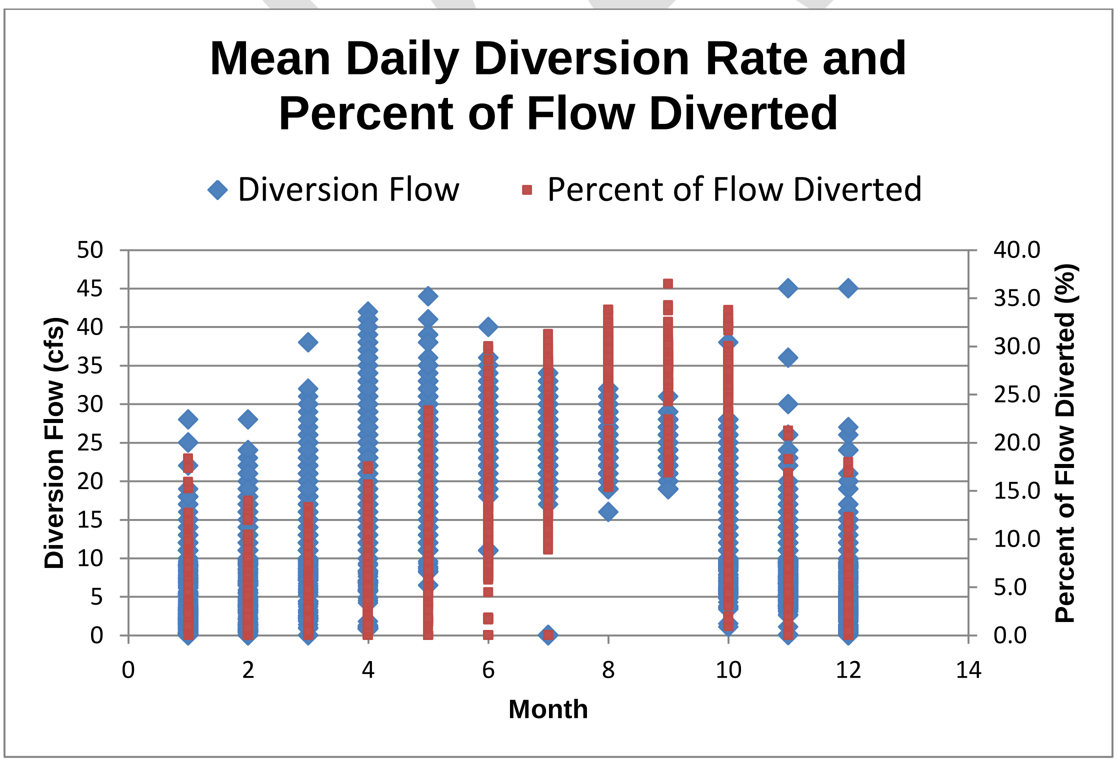

Figure 7. Mean daily diversion rate and percent of flow diverted since 1988.

Target Species

Anadromous species with consistent runs up Deer Creek include spring- and fall-run Chinook salmon, Central Valley steelhead trout, and Pacific lamprey. All of these species are native to Deer Creek and are considered the target species for this project. The particular life stages targeted for these species are both adult migration and juvenile rearing. Figure 8 represents the fish distribution within the anadromous reaches of Deer Creek.

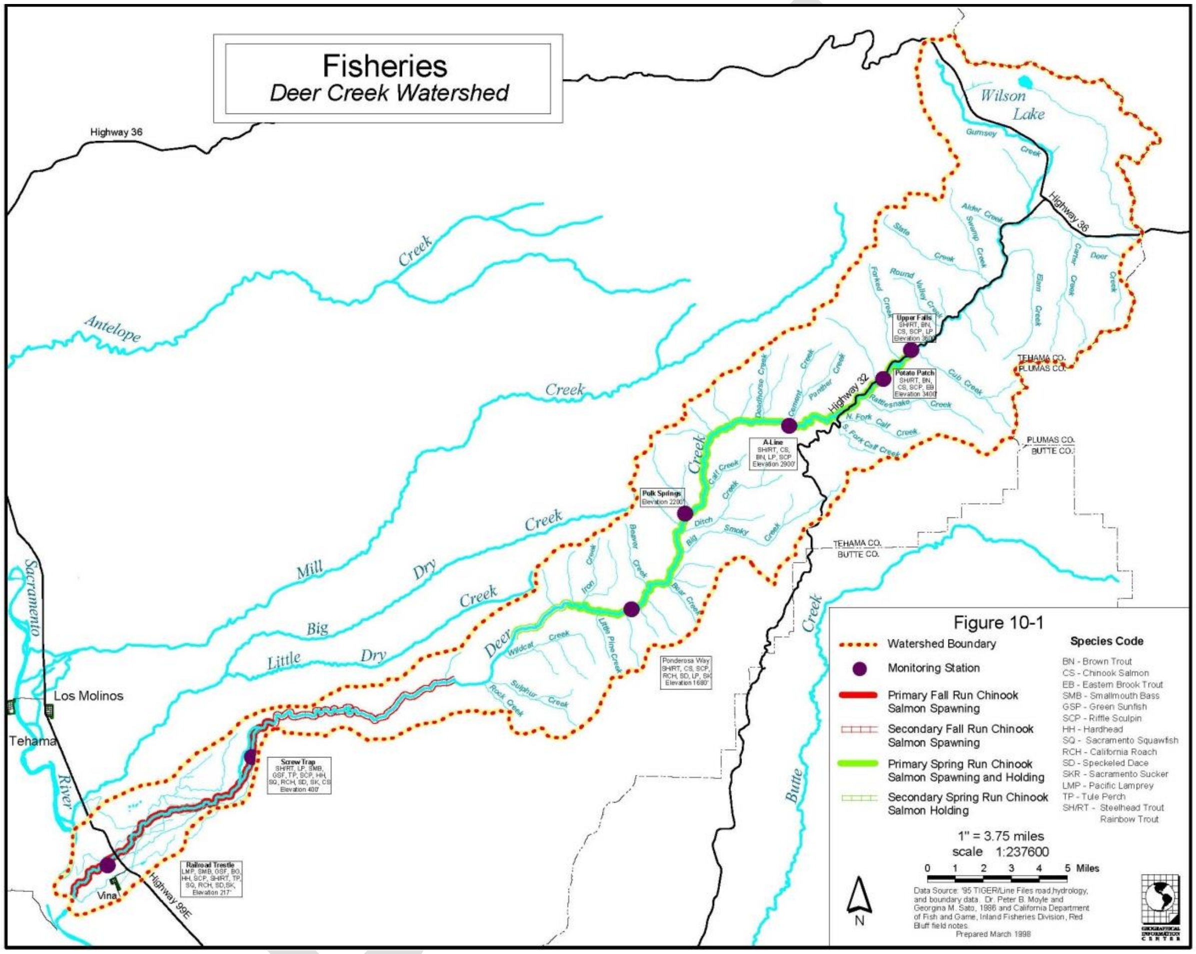

Figure 8. Deer Creek Fisheries Map (Source: Deer Creek Management Plan, 1998)

Adult spring-run Chinook salmon have been documented migrating upstream into Deer Creek as early as March and extends through early July. Spring-run will hold in the higher elevations within the canyon reach, over summer in deep cold pools until they spawn anytime in August through October. The known range of adult spring-run holding habitat extends from Upper Falls downstream to Ponderosa Way.

Adult fall-run Chinook salmon migrate into the creek from July through October and spawn anytime in October through December. Central Valley steelhead trout migrate during the first heavy storms in the fall which can be as early as October, but they migrate primarily in December through February.

Juvenile summer and winter rearing habitat is considered a major factor in the survival and production of Chinook salmon Unlike Chinook salmon adults, which stop feeding once they enter a system and die soon after spawning, juveniles spend some time (up to three years for some races) in freshwater prior to outmigration. The downstream migration appears to occur from late-winter through spring when stream flow increases Essential to juvenile salmonid survival during their outmigration to the ocean is an unimpaired migration corridor (Armentrout et al,1986).

Pacific Lamprey is a species of concern. In 2012, the Pacific Lamprey Conservation Initiative was developed to promote the implementation of conservation measures for Pacific Lamprey in Alaska, Washington, Oregon, Idaho, and California. Although Pacific Lamprey were historically widespread along the West Coast of North America, their abundance is declining. Threats to Pacific Lamprey include but not limited to; restricted mainstem and tributary passage, reduced flows, dewatering of streams, stream and floodplain degradation, and degraded water quality (Columbia River Basin Lamprey Technical Workgroup, 2004).

Fish Passage Issues

Inadequate flow for upstream passage is the most significant problem in Deer Creek. Reduced in-stream flows from the three diversions and other riparian water rights can adversely affect stream habitat in the lower reach, particularly during late spring, summer, and fall. Currently, there are no minimum in-stream flow requirements. DCID has water rights that allow a diversion of up to a third of Deer Creek flow and Stanford Vina Ranch Irrigation Company (SVRIC) can divert the remaining water in the creek.

During portions of the year the dam can partially impeded or block fish passage. Water currently sheets over the apron which provides little depth for fish to navigate and jump over the dam (Figure 9). The mean daily flow in Deer Creek shown in Figure 9 is about 98 cfs while DCID is diverting 24 cfs.

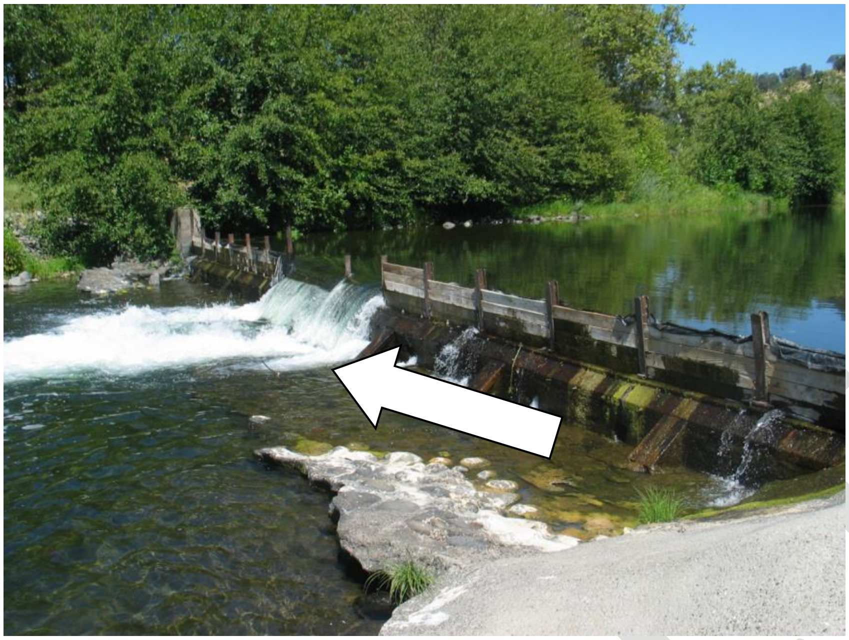
Figure 9. Water sheeting over apron (August 12, 2005).

In late October 2005, DWR staff observed fish stacked up behind the dam trying to leap over the dam. Because it was towards the end of irrigation season, there were more openings in the dam allowing for more water in the creek. There were two possible routes for fish passage, the center 8-foot section and a 4-foot section on the left side of the dam (Figure 10). While watching the fish, most fish chose the 4-foot left section of the dam as the passage route. The mean daily flow in Deer Creek shown in Figure 10 is 103 cfs, while DCID is diverting 16 cfs.


Figure 10. Fall-run Chinook salmon attempting to leap over the dam (October 31, 2005).

Topographic Survey

During the fall of 2005, DWR staff conducted a topographic survey of the project area. A total station was used to collect topographical data including ground shots, existing structures, and cross sections upstream and downstream of the dam. This data was used to create a 1-foot contour map (Figure 11).

In 2012, additional surveying data was collected to increase the area of the topographic map for the project in order to analyze alternatives that were identified by TAC members. GPS and total station equipment was used to collect the additional survey data. The additional data was used to update the original 1-foot contour map. Horizontal coordinates for the project are based on the North American Datum of 1983, California State Plate Zone 1, US Feet. The elevations are relative to the North American Vertical Datum of 1988, US Survey Feet.

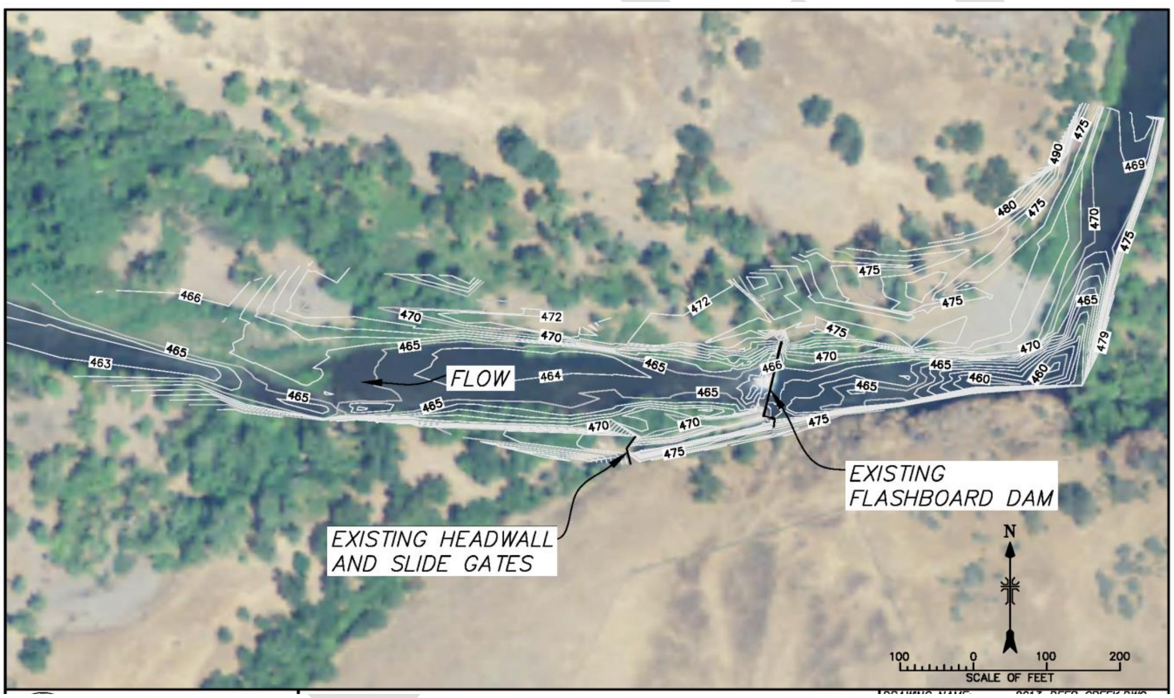

Figure 11. Topographic map of project area.

Existing Geomorphic Conditions

The geomorphic information listed below was mostly compiled from the *Lower Deer Creek Ecosystem Restoration and Flood Management: Feasibility Study and Conceptual Design – Existing Conditions: Hydrology and Geomorphology Technical Memorandum* (Tompkins and Kondolf, June 2007).

Deer Creek originates on the west slope of Mount Lassen and flows through Deer Creek Meadows. Downstream of the meadows, the creek flow into a deeply incised canyon underlain by the Tuscan Formation that is composed of ancient volcanic mudflows (Ely 1994). Channel form in the canyon is controlled by bedrock outcrops and the channel width is controlled by the canyon walls. Immediately downstream of the canyon (RM 10.5), the creek flows out onto an alluvial fan, which extends to the confluence of the Sacramento River. The dam is located at approximately RM 10.5.

The creek within the project area is incised in cemented alluvium units (Riverbank Formation, Red Bluff Formation, and other terrace gravels). The alluvial fan is bounded by bluffs formed of older geologic units. The channel upstream of the dam is composed of coarse cobbles and the creek is bounded by a steep-walled canyon. Downstream of the dam the channel is composed of large cobble and the creek has low channel banks where overbank flow occurs quite regularly. According to pebble count data collected near the project area in the early 2000's, the bed particle sizes are as follows:

- D_{16} is 23 -84 mm (0.9 – 3.3 inches)
- D_{50} is 45 -190 mm (1.8 – 7.5 inches)
- D_{84} is 81 – 290 mm (3.2 – 11.4 inches)

The creek channel in this area has not changed much since 1938. The flood corridor width has only changed about 0.02 percent since 1938. The low flow channel width has increased by approximately 7.2 percent since 1938. There is no visible evidence that suggest the creek bottom is changing significantly over time. There has been some localized scour occurring downstream of the dam due the plunging flow over the dam.

This reach of the creek has classic riffle-pool morphology and likely has high sediment transport capacity during high flows. There is a riffle approximately 600 downstream of the dam that is likely controlling the water surface elevation downstream of the dam. Immediately upstream of the dam is a very sharp bend with a deep pool that may provide holding habitat for adult salmonids. Approximately 600 upstream of the dam another riffle exist with a low lying point bar on the left bank. The slope between the two riffles is about 0.3 percent.

Hydrologic Investigation

The hydrologic investigation included analyzing the historical flow data in the Deer Creek Watershed, determining fish passage flows, and analyzing the staged differential data collected in 2005.

Historical Flow

There is a USGS Gage #11383500 in Deer Creek near Vina, California. The period of record for this gage is from October 1911 to September 1915 and from March of 1920 to the current year. This gage is located approximately 0.5 miles upstream of the dam.

A flood flow frequency curve was developed to determine the flood frequency flows for Deer Creek. The frequency curve, observed peak flows, and upper and lower confidence limits are shown in Figure 12. The curve was created using the Log-Pearson Type III distribution based on maximum flood peaks for each year from 1961 through 2011. The 100-year, 50-year, 10-year, and 2-year flood events are 27,800 cfs, 23,200 cfs, 13,900 cfs and 6,000 cfs, respectively.

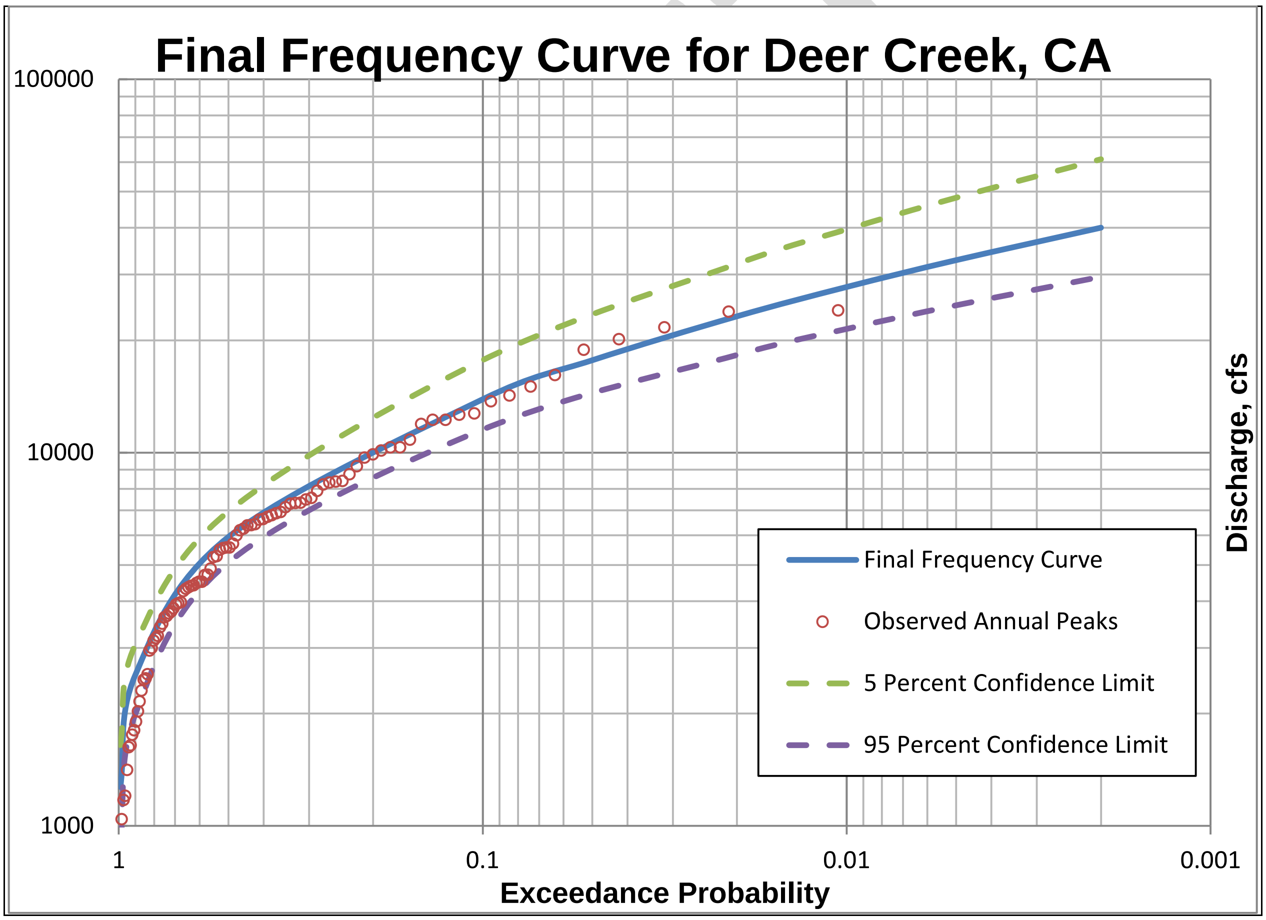

Figure 12. Flood Frequency Curve for Deer Creek during 1961 – 2011.

Stage Differential

DWR staff monitored the upstream and downstream stage differential at the dam during the 2005 irrigation season to determine the head differential at the dam during that irrigation season. From March 25th through October 25th, 2005, pressure transducers were used to measure the water surface elevations up and downstream of the dam every fifteen minutes. Staff gages were installed in the creek, one placed upstream of the dam on the concrete wall along the upstream side of the diversion entrance and the second one placed about thirty feet downstream of the dam. The staff gages were used to calibrate the pressure transducers.

Average daily water surface elevation difference across the dam and mean daily flow in Deer Creek is shown in Figure 14. One of the pressure transducers were tampered with sometime around May 19th, as indicated on the graph. On June 28th, while visiting the site to download data, the pressure transducer was found out of the water. The maximum "real" head differential measured was about 3.9 ft during late September 2005.

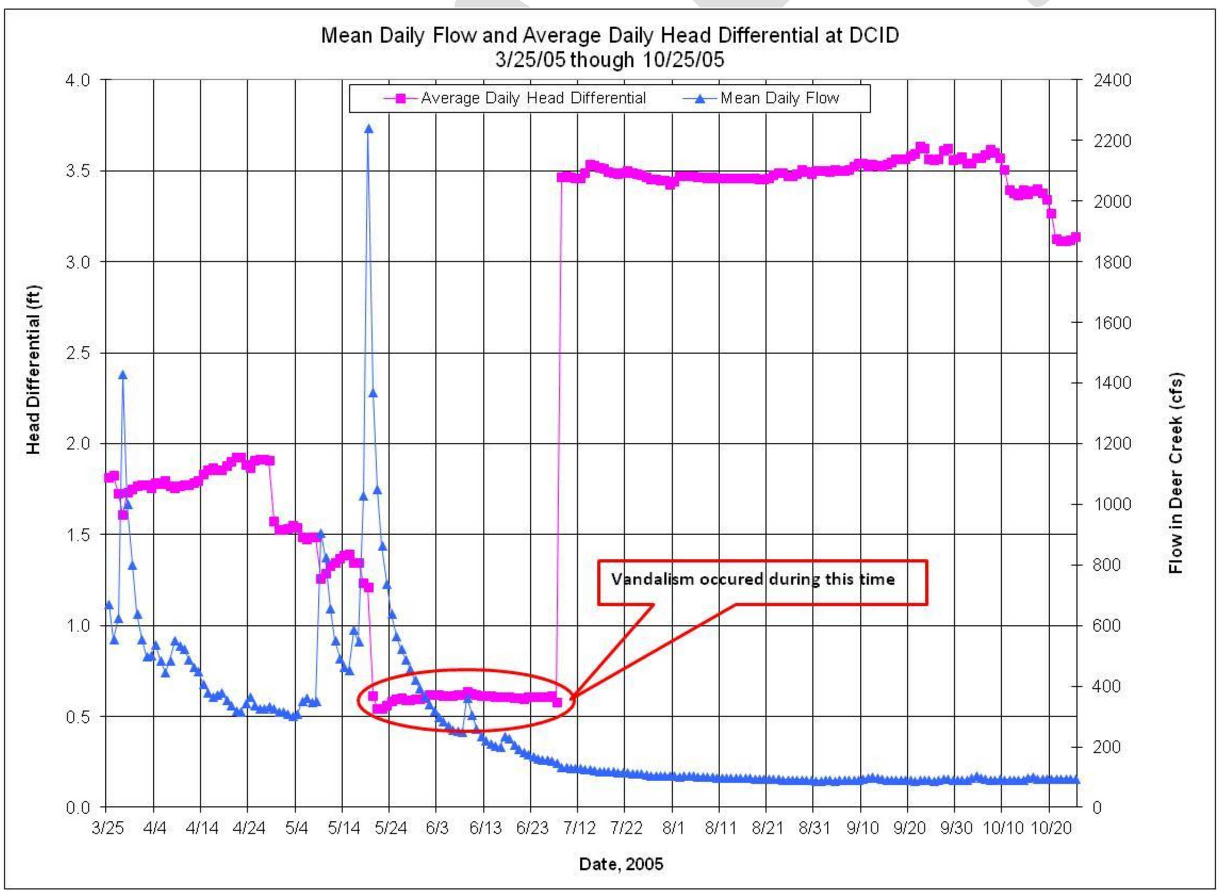

Figure 14. Head differential at the dam.

Passage Assessment

There are no records of the daily operation of the flashboard dam, pulling and placing boards, which makes it difficult to analyze when and at what flows fish can currently pass over the dam.

Spring-run Chinook salmon are able to pass over the dam based on the survey data conducted by CDFW above the dam. But what is not known is the amount of time the fish are delayed as a result of the dam.

A one dimensional hydraulic model (HEC-RAS) was used to estimate the head differential over a range of flows for two scenarios. One scenario is when the boards are placed in the dam and the other scenario is when no boards are in the dam. Water surface elevations were surveyed in 2012 during a flow of 90 cfs in Deer Creek and DCID was diverting 25 cfs with most boards placed in the dam. The HEC-RAS model was calibrated for this scenario. A range of flows from 40 cfs to 3,300 cfs was modeled.

A high flow model was also calibrated for the scenario when no boards are place in the dam. Water surface elevations were measured for flows of 1,400 cfs and 3.300 cfs and used to calibrate the high flow model. Table 2 represents the modeling results for both the boards in and boards out scenario.

Table 2. HEC-RAS results

Creek Flow (cfs)	**Boards Out/Head Differential (ft)**	**Boards In/Head Differential (ft)**	**Diversion Flow (cfs)**
40	3.1	3.9	13 cfs
60	3.0	3.8	20 cfs
90	2.4	3.2	25 cfs
400	2.4	3.2	40 cfs
1000	1.9	2.8	
1400	1.1	2.0	
3300	1.0	N/A*	

*Flow was not contained within the cross section

HEC-RAS results indicate there is about a 2- to 4-foot head differential during the boards in scenario. This range is in agreement with the water surface elevations measured during the 2005 irrigation season (shown in Figure 14). HEC-RAS results for the boards out scenario imply that a swim through condition could exist at flows 1,400 cfs or greater.

Summary of Alternative

Lower Diversion Ditch

This conceptual alternative includes lowering the diversion ditch approximately 1-foot, constructing a rock ramp downstream of the dam, and replacing the existing Parshall flume, fish screen and headgate structure. The dam would be left in place, but not operated with flashboards.

The dam is needed with either 1- or 2- foot lowering of the ditch because at flows of 90 cfs or greater in Deer Creek, the water surface elevation is not high enough to meet DCID water demand.

The current slope of the ditch varies throughout its length of 3.5 miles from 0.3- to 0.6-percent. Lowering approximately 3,000 feet of the ditch 1-foot beginning at the diversion point will create a 0.31 percent slope. This will decrease the current slope from 0.35 percent to 0.31 percent, but will not adversely affect the current capacity of the diversion ditch.

The rock ramp would span the entire width of the channel and start at the dam crest. The slope of the ramp would be no more than 4 percent. The rock ramp would be designed to ensure the creek below the dam meets fish passage criteria.

The existing ditch, Parshall flume, fish screen and juvenile return would be replaced to coincide with the lowering of the ditch approximately 1-foot. The project would impact about 1 acre. The layout is shown in Figure 22.

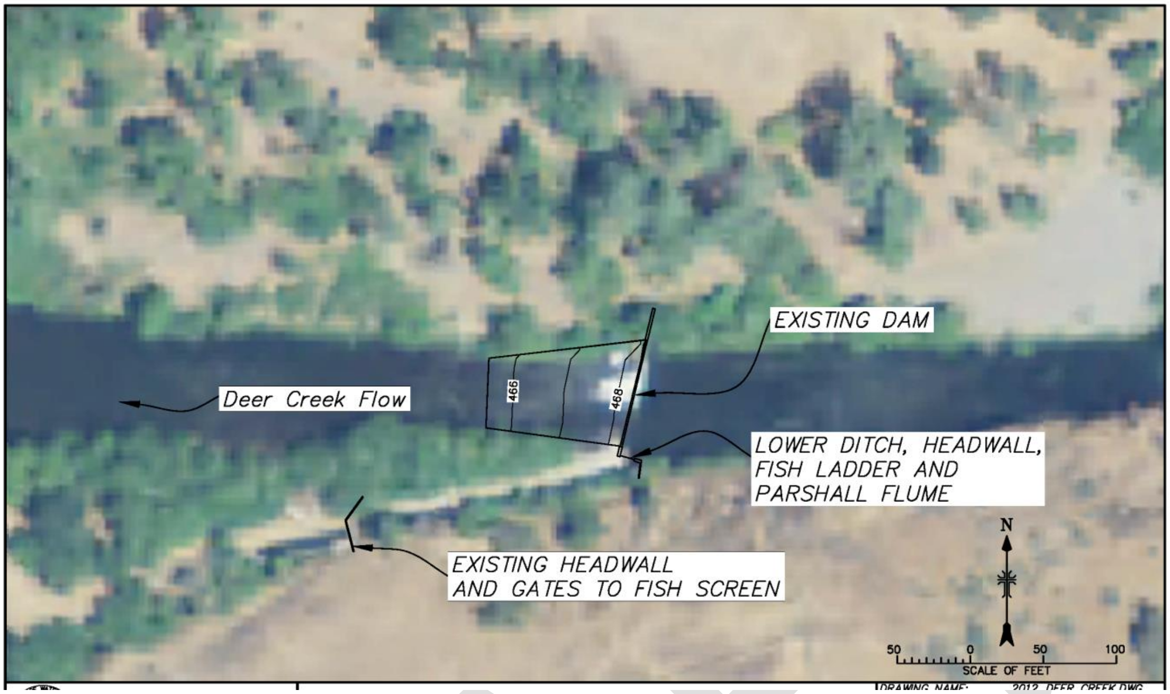

Figure 22. Alternative 5 Plan View– Lower ditch and construct rock ramp.

Construction of this alternative could include developing an access road to the work area along the left bank, modifying the existing dam apron to construct the rock ramp, importing small and large rock, excavation of 3,000 feet of the ditch 1-ft beginning at the entrance with a slope of 0.31 percent, spoiling the material, remove and construct the existing facilities at a lower elevation (fish screen, headgates, Parshall flume), riparian planting, and contour grading. Construction would occur during the summer and fall when flows are low. Dewatering activities would likely include installing a coffer dam to isolate the work area, installing pumps to dewater the work area, and constructing a settling basin to reduce the turbidity levels of the pumped water.

The entire project footprint falls on three different landowners.