Removal of Dwinnell Dam and Alternatives

Draft Concepts Report

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Abstract

Passage of salmon and steelhead to the upper Shasta River was blocked by the construction of Dwinnell Dam in 1928. Approximately 22 percent of the salmon and steelhead spawning and rearing habitat of the Shasta River was lost with the construction of the dam and reservoir. Spring run Chinook salmon that depended more on the upper watershed became extinct, while fall run Chinook salmon, coho salmon, and steelhead suffered severe declines in numbers from the loss of the upper watershed and long-term degradation of lower watershed habitats. Passage to the upper river could be restored by installing a fish ladder on the dam, trapping and hauling fish around the reservoir, dam removal, or providing a bypass route around the reservoir. These four alternatives are evaluated in this report. All four alternatives would require substantial habitat restoration including development of water supplies and improvements to spawning and rearing habitat and fish passage both above and below the Dam to achieve all the potential benefits. There are approximately 12 miles of accessible habitats to salmon and steelhead above Dwinnell Dam in the mainstem Shasta River, plus a similar amount in tributary creeks. There are approximately 16 miles of accessible habitat in Parks Creek. Dam removal would allow access to all of these habitats, including 4 miles in the reservoir reach, plus improve access and habitat to the six miles of Shasta River below the Dam. Ladder and Trap-and-Haul alternatives would allow access to only 8 additional miles of the upper Shasta River. The Bypass Alternative would allow access to only about 6 miles of the upper Shasta River and all but several miles of tributaries. The Bypass Alternative would have little direct benefit to the 6 miles of the Shasta River above or below the Dam, but would lead to substantial improvement to habitat of the lower 8 miles of Parks Creek. Both the Dam Removal and Bypass alternatives would lead to substantial improvements in water supply, water quality, and sediment transport in the lower Shasta River below the Dam and Parks Creek, respectively, which gives these alternatives substantial advantage over the Ladder and Trap-and-Haul alternatives. The added benefit of the Dam Removal Alternative over the Bypass Alternative is essentially the six miles above and below the dam, as well as four miles of Carrick Creek, a spring-fed tributary in the reservoir reach. The added benefit of the Bypass Alternative over the Dam Removal Alternative is added Bypass habitat in the upper watershed plus substantial additional benefits to the lower eight miles of Parks Creek. In terms of schedule and cost, the Bypass Alternative has a substantial advantage over the Dam Removal Alternative. Both alternatives would require substantial cost of water supply development in addition to infrastructure and habitat restoration.

Introduction

The removal of Dwinnell Dam has been proposed to help recover salmon and steelhead populations in the Shasta River, a major tributary and wild salmon producer of the Klamath River. The National Research Council (NRC 2003) concluded "…*serious evaluation should be made of the benefits to Coho Salmon from elimination of Dwinnell Dam*." As a consequence, dam removal is being considered along with restoration of the upper Shasta River watershed to restore what are dwindling runs of fall run Chinook salmon, listed coho salmon, and steelhead. Dwinnell Dam represents a significant passage impediment for salmon to the upper river basin, but also captures most of the upper basin water supply that is not already used in the upper basin for use in the lower basin. Water stored in Dwinnell Reservoir is conveyed to agricultural and municipal water users downstream in Shasta Valley, thus little upper watershed water directly reaches the lower river. The major upper Shasta River tributary not blocked by the dam, Parks Creek, also has most of its winter-spring flows diverted to Dwinnell's reservoir. Little of the upper basins water including the upper Shasta River and Parks Creek reaches the lower Shasta River, except in wet years when the dam spills and Parks Creek flood flows overwhelm the 300-cfs capacity of the diversion canal to Dwinnell Reservoir.

There are several ways to bring the upper watershed back into use by salmon and steelhead. One is removal of Dwinnell Dam. A second is providing fish passage facilities at the dam. A third is constructing a bypass around the dam and reservoir. All of these potential measures require restoration of the upper watershed to accommodate potential runs of salmon and steelhead. Measures would involve restoring natural processes and habitat that have been lost above and below the dam because of the dam, reservoir, or their operations, as well as habitat degradation from over a century of development and use. Such restoration would include changes that would improve river flows, sediment transport, water temperature, and water chemistry, as well as improvements to the physical habitat of the stream channels. Fish passage problems associated with water diversions other than Dwinnell dam and reservoir would also need to be resolved in both the upper and lower watershed. Improvements can be made to spawning and rearing habitats by conserving cold water from springs, rehabilitating springs, gravel introductions, riparian restoration, large woody material introductions to stream channel, channel changes, fencing to limit cattle access to streams, and reductions in agricultural tailwater inputs of warm poor-quality water.

This report summarizes the existing environmental conditions in the watershed and how dam removal and each of the before mentioned alternatives would address the issues, and how the salmon and steelhead populations might benefit from the alternatives. Each alternative would necessarily involve habitat improvements to the lower and upper river systems, which is a common theme of Shasta River salmon recovery. More details on the various restoration options and plans are provided in the recent recovery strategy provided by the Shasta Valley Resource Conservation District (SVRCD 2011).

Since construction of Dwinnell Dam and the diversion from Parks Creek to Lake Shastina in 1928, anadromous salmonid access to the Shasta Basin's headwaters has been blocked. The spring run Chinook population that spawned and reared in the upper river virtually became extinct immediately upon dam construction. Fall run Chinook and coho salmon, as well as steelhead that used the upper river were also confined to the lower river, where they have suffered severe declines, as the lower river lost much of its water and sediment supplies, and suffered its own development impacts. Fall Chinook runs that numbered 80,000 in 1932 had fallen to as low as 900 in the 1990s. The coho run has fallen to less than one hundred spawners. Steelhead numbers are believed to have fallen to similar levels.

The SVRCD and several collaborators (SVRCD 2011) have evaluated existing information and identified key informational gaps in developing a study plan for Shasta River salmon recovery. The study plan identifies the scientific information needed to guide and prioritize actions that will move Shasta River salmonid populations toward recovery. However, that plan focuses only on potential improvements to the lower river, especially the Big Springs Complex in the middle river below Dwinnell Dam. This report focuses on the upper river recovery options including dam removal.

The Montague Water Conservation District (MWCD), the owner of the dam and reservoir, and provider of the water, has conducted its own review of the feasibility of dam removal and the ramifications to water rights holders downstream in Shasta Valley (Potletch 2009). That review and many other references reviewed in this report are listed in the references at the end of this report.

A common theme of most of these references is that time is of the essence because the coho salmon numbers are extremely low and actions are needed quickly to save the coho population from extinction. This review contains a range of options that could be employed in short and long term perspectives, and under a sense of urgency.

While the main focus of this report is on the state and federal listed coho salmon, much of the information and potential benefits also apply to spring-run and fall-run Chinook salmon and steelhead.

Description of the Shasta River Watershed

Shasta River watershed is the first major watershed downstream of Iron Gate Dam on the Klamath River (Figure 1). The watershed is approximately 800 square miles of the nearly 16,000 square-mile Klamath River basin. The Shasta River originates in the higher elevations of the Eddy Mountains, southwest of the City of Weed in Siskiyou County, California. The river flows northerly for 50 miles through the Shasta Valley and Canyon to the Klamath River approximately 180 miles upstream from the Pacific Ocean. Numerous springs and tributaries enter the Shasta River through the Shasta Valley with the principal source of spring flow coming from Mt Shasta.

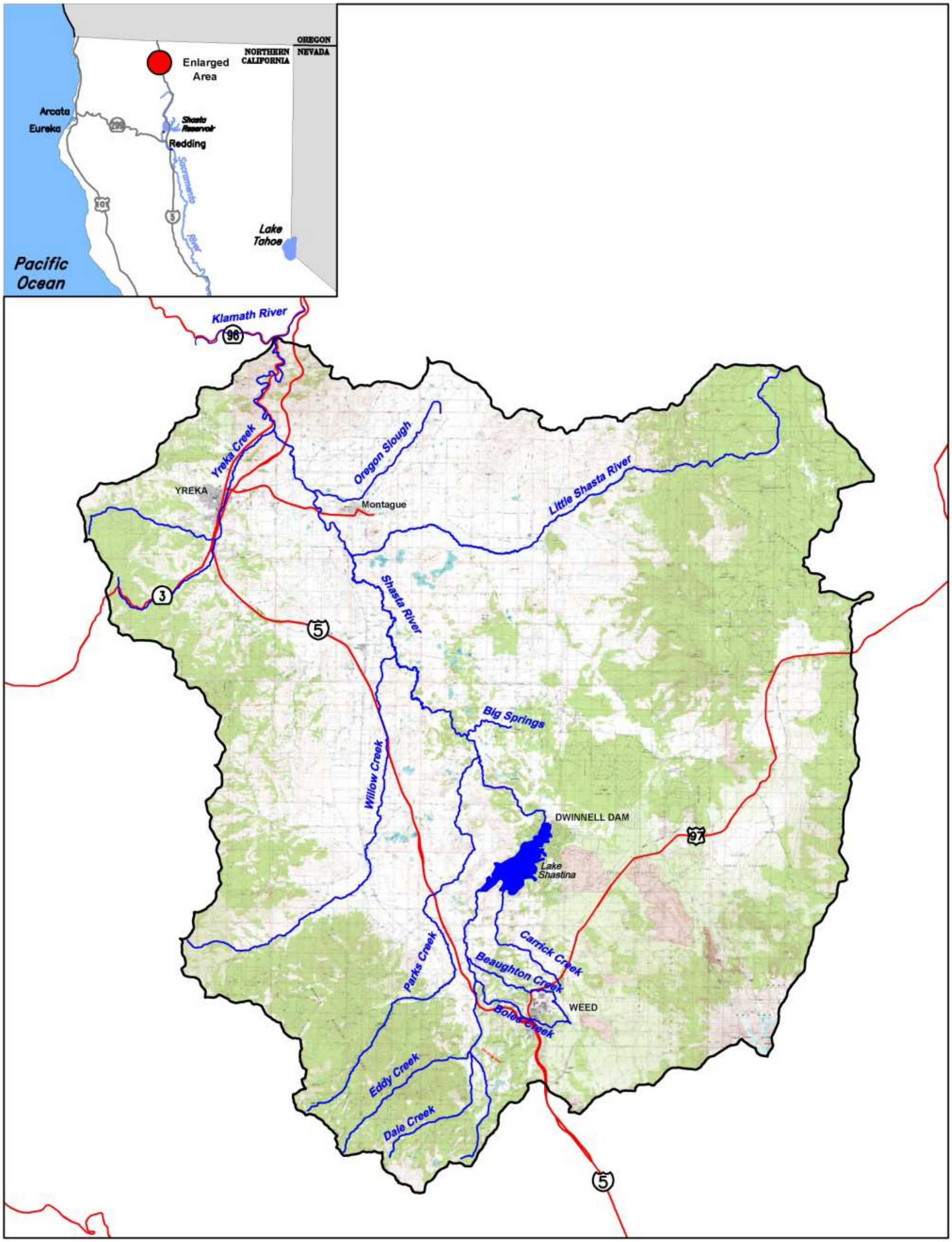

Figure 1. Shasta River watershed. (Source: SVRCD 2011)

Elevations in the upper watershed range from 14,162 feet at Mount Shasta to approximately 2,750 feet at the base of Dwinnell Dam. The high elevation terrain captures significant amounts of rain and snow, with precipitation ranging from 70 inches at the highest elevations to less than ten inches at the lower elevations. The large amount of rain and snow at high elevation creates surface flows forming Dale Creek and Eddy Creek, the western headwaters of the Shasta River. The eastern headwaters of the Shasta River are formed from springs, especially from the flanks of Mount Shasta. The springs form numerous tributary creeks, including Boles Creek, Beaughton Creek, and Carrick Creek. Upper Parks Creeks has significant rain and snowmelt from Mt Eddy in the Trinity Mountains; however flows are highly seasonal with limited springs.

The watershed has two major sections: the upper watershed above Dwinnell Dam (about 125 square miles) and the lower watershed (675 square miles) below Dwinnell Dam. The major tributary subwatersheds below Dwinnell Dam include the Little Shasta River, Yreka Creek, Big Springs Creek, and Parks Creek. Above Dwinnell Dam, the major subwatersheds are Carrick Creek, Beaughton Creek, Boles Creek, Dales Creek, and Eddy Creek, as well as the mainstem upper Shasta River. For the purposes of this report, Upper Parks Creek is considered part of the Upper Shasta River watershed above Dwinnell Reservoir because most of the Parks Creek water is diverted to the reservoir. The following description focuses on the upper watershed. Detailed descriptions of the lower watershed are provided in SVRCD (2011).

Shasta River Hydrology

Unique to the Shasta watershed are the major creeks fed by springs from Mt Shasta, including Big Springs, Beaughton, Boles, and Garrick creeks on the east side of the Valley. Together with the smaller springs they provide approximately 200 cfs of base flow to the Shasta River. The other watersheds flow principally from Mt. Eddy in the Trinity mountains on the west side of the Valley. Base flow from these west side watersheds is less than 50 cfs. Two lower watershed streams are Yreka Creek and Little Shasta River, which provide little to the base Shasta River flow in summer. Yreka Creek and the other west side streams have higher winter-spring runoff from higher winter precipitation and runoff.

Much of the higher winter-spring flows of Parks Creek, the largest west side watershed, are diverted at rates up to 300 cfs to Dwinnell Reservoir from October 15 to June 15. Dwinnell storage rights include 35,000 acre-ft from the upper Shasta River and 14,000 acre-ft from upper Parks Creek. As stated earlier, most of the upper watershed water is stored in Dwinnell Reservoir and does not reach the lower river except in wetter years in the form of dam spill or lower Parks Creek flood flows. The effect of Dwinnell Reservoir on lower Shasta River hydrology is shown in Figure 2

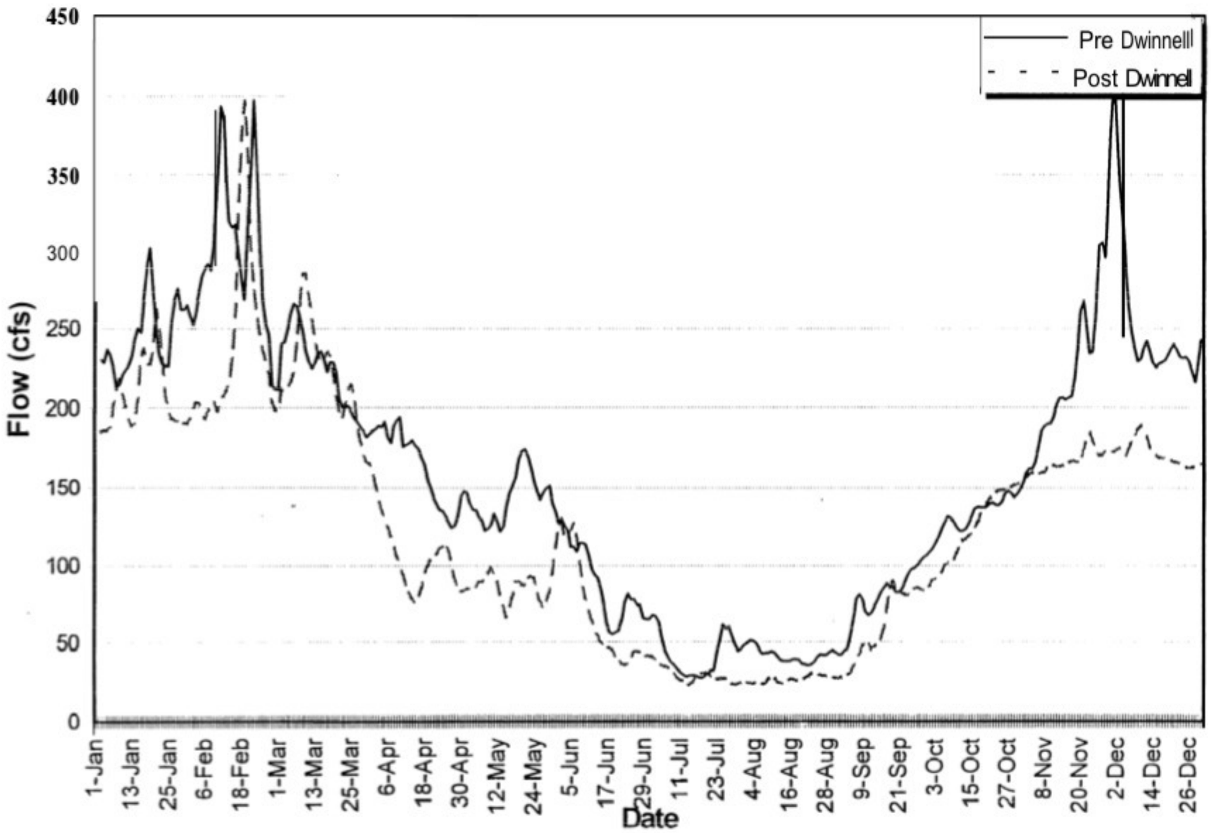

Figure 2. Shasta River hydrology pre and post Dwinnell (based on ten-year daily averages of data collected at Montague USGS Gage). (Source: CDFG 1997)

Most of the summer base flows of the entire Shasta River basin today support Shasta Valley irrigation upstream and downstream of Dwinnell Dam. Big Springs Creek at RM 34 in the lower watershed with nearly half the total watershed base flow contributes most of the spring flow to the lower river – about 70 cfs – while the remainder is diverted for agriculture at the headwater springs. Most of the Big Springs Creek flow that reaches the river is subsequently diverted from the lower Shasta River for irrigation. Other springs potentially contributing to the flow of the lower Shasta River below Dwinnell Dam including Clear and Hole-in-the-Ground on the Shasta River, and Kettle, Bridgefield, and Duke on lower Parks Creek in total provide 20 cfs or more, most of which is diverted for irrigation during the April to October irrigation season. Some spring water and irrigation returns contribute to the limited summer base flows of the lower river.

In the upper watershed summer base flows are also very low because of water diversions. Only a small amount of water (on average less than 10 cfs) reaches Dwinnell Reservoir from the upper Shasta River. Flows from upper to lower Parks Creek are minimal also because of irrigation season diversions. Nearly all the summer base flows of the upper Shasta River and Parks Creek are carefully distributed for irrigation or municipal water supplies.

Winter flows in the upper Shasta River reach several hundred cfs coming into Dwinnell Reservoir with much of that flow coming from the Parks Creek diversion. In the upper river flows vary with rainfall but are generally near or above the summer baseflows of about 100 cfs. About 15-20 cfs winter base flow enters from Parks Creek above the MWCD diversion. Coming into Dwinnell Reservoir from the upper Shasta River flows are base flows of about 80 cfs (about half from Beaughton, Boles, and Carrick Creek springs) with added runoff flow from rainfall or snowmelt from Dale and Eddy Creeks, and the upper mainstem Shasta River.

In the lower river below Dwinnell, winter flows are generally near the base flow of springs, as little of the upper watershed runoff reaches the lower river. With little or no irrigation in winter, flows below the Big Springs reach 100-120 cfs or higher depending on local precipitation and additional small spring inputs in addition to the 85 cfs from Big Springs. Of that amount about 20-30 cfs comes from springs and runoff from the river above Big Springs made up the flow in the river at the mouth of Parks Creek. With no irrigation demands below the reservoir, flow in the river below Dwinnell Dam and in lower Parks Creek is limited to seepage and springs. With additional inflow from Yreka Creek and Little Shasta River, flows average near 300 cfs in the canyon reach, but may exceed 1000 cfs in high rainfall or snowmelt conditions.

Water Rights and Diversions

Upper Shasta River

According to the adjudication, the total number of water rights above Dwinnell Dam is 145 active diversions with a total appropriated rate of 152 cfs. The largest right is approximately 30 cfs. There are 67 water diversions on the upper mainstem Shasta River, headwater forks of the Shasta River, and several springs associated with the mainstem Shasta River upstream of Dwinnell Reservoir. The total summer (March 1 – November 1) diversion allocations amount to 112 cfs, while permitted winter (November 1 – March 1) diversions are 19 cfs. There are 21 summer diversions on Beaughton Creek and associated springs with a total diversion rate of 10 cfs. There are 30 active diversions located on Boles Creek and numerous associated springs. The total summer diversion rate in this watershed is 18 cfs. There are approximately 27 active diversions on Carrick Creek and its numerous associated springs. The total summer diversion rate in the Carrick Creek watershed is 12 cfs, while the winter diversion rate is 3 cfs. The number and volume of these adjudicated diversions has not been verified by a watermaster or other regulatory agency.

While a substantial portion of the water from the upper watershed diversions (not including Dwinnell) is used in the upper basin, some also is transferred via ditches to the lower watershed. The Yreka Ditch diverts water from the upper Shasta River upstream of Edgewood to the west side of the lower Shasta Valley. Most of the Dwinnell Reservoir water is diverted to the east side of the lower Shasta Valley via MWCD's main canal.

Perhaps most unknown is the diversion to the upper Shasta River from the North Fork of the Sacramento River of up to 15 cfs of water in winter for storage in Hammond Reservoir for summer irrigation in the upper Shasta Valley. The diversion site is on the south side of Mt. Eddy and transfers water northward via Eight Mile Ditch to Hammond Reservoir southwest of the City of Weed, from where it is distributed for water right holders in the upper Shasta River valley during the irrigation season.

Dwinnell Reservoir has rights to store 49,000 acre-ft of water from the upper Shasta River and Parks Creek. The diversion from Parks Creek to the upper Shasta River near Edgewood has a right of 14,000 acre-ft, most of which is provided in the winter at rates normally up to 145 cfs, but with a 300 cfs capacity in wet years. Essentially, as water flow increases in winter, most of the Parks Creek water is diverted to Dwinnell Reservoir via the upper Shasta River.

The diversions from the upper Shasta River and the MWCD Parks Creek diversion are not screened. Areas of these watersheds above Dwinnell Dam on the Shasta River have no anadromous fish, so no screens have been required. Similarly, on Parks Creek anadromous fish usually do not reach the MWCD Parks Creek diversion to Dwinnell Reservoir, thus it is not screened. However, several of the smaller diversions on Parks Creek upstream of the diversion to Dwinnell Reservoir are screened, and plans call for screening the MWCD Parks Creek diversion to Dwinnell Reservoir, because anadromous fish do have access to upper Parks Creek if sufficient flow and passage conditions are available.

Screening the diversions, especially the Parks Creek diversion is a very costly proposition. The existing head gates at the MWCD Parks Creek diversion typically remain fully open during the diversion period to allow the maximum flow possible to be diverted from Parks Creek into the diversion canal. The cost of this screen alone is estimated at near $2 million. The cost of screening the dozens of other smaller diversion is estimated at approximately $23,000 per diversion.

Some of the diversions also require fish passage facilities. At the MWCD Parks Creek diversion there is a four-foot hydraulic drop that hinders upstream passage. A fish ladder is thus part of the screening project being planned by MWCD and CDFG.

Lower Shasta River

Water diversions are also extensive on the lower Shasta River taking up to 90 percent of the river flow in the irrigation season. The Big Springs Irrigation District has rights to 30 cfs of Big Spring’s 85 cfs. The Grenada Irrigation District has rights up to 40 cfs of the lower Shasta River below Big Springs (most of which is provided by Big Springs). The Siskiyou Water Users Association (SWUA) has rights totaling 40 cfs from the lower Shasta River. Water rights account for 113 cfs of the total 220 cfs baseflow of the lower Shasta River. Some lower Shasta River ranches also have water rights from lower Parks Creek and Dwinnell Reservoir storage. Reservoir water is released to the lower river from Dwinnell Dam to satisfy the water rights of ranches immediately below Dwinnell Dam. These ranches also have rights to capture larger springs including Kettle and Bridgefield Springs on lower Parks Creek, Little Spring Creek a tributary of Big Springs Creek, and Hole-in-the-Ground Spring on the lower Shasta River above Big Springs Creek. Diversions on these larger ranches are not monitored by the water master.

Parks Creek

There are several dozen active and inactive diversions on Parks Creek that take most of the water during the irrigation season (Figures 3 and 4). Twenty four of these are classified as Active Decreed Diversions and are serviced by the State water master. These do not include the ranch diversions from the lower creek and springs near the Shasta River. Many of these are small diversions including several high in the watershed of the North Fork on Forest Service land. The water master distributes roughly 10 cfs of the Parks Creek baseflow to these diversions during the irrigation season.

Figure 3. An upper Parks Creek water diversion. (Source: state water master)

Parks Creek Diversion 182 – Looking down ditch at the DFG fish screen.

Figure 4. An upper Parks Creek diversion with fish screen. (Source: State water master)

Little flow during the irrigation season reaches lower Parks Creek below the I-5 crossing. Some winter flow passes through to the lower creek, but most is diverted to Dwinnell Reservoir at the MWCD diversion canal.

Lower Parks Creek below I-5 in the lower Shasta River valley picks up considerable spring and irrigation return flows including flow from Kettle, Duke, and Bridgefield Springs. Most of the spring flow is diverted to pastures during the irrigation season but contributes considerably to the streamflow in the non-irrigation season. Some of the spring flow is believed to come from Dwinnell Reservoir leakage (Bridgefield Spring), although Kettle Springs is known to have flowed prior to Dwinnell Reservoir.

Water Quality

The water quality of the upper and lower Shasta basin suffers from many degradations and natural geologic processes. For salmon recovery, the main water quality issues are water temperature, sediment, dissolved oxygen, and excessive nutrients. With low flows from natural low seasonal rainfall and many water diversions, an abundance of irrigation tailwater, proliferation of aquatic plants, and the warm dry summer climate, the river suffers from high water temperature, high turbidity, and low dissolved oxygen. These conditions lead to poor growth and survival of young salmon and steelhead. Water temperatures in excess of 25ºC that are lethal to salmonids are common in the summer in many areas. Sublethal temperatures only occur in specific refuge areas near springs or high in the watershed. High aquatic plant growth from an abundance of fine sediment and nutrients, along with warm water, causes low night-time dissolved oxygen levels that are stressful or lethal to salmonids. The high fine sediment loads in stream spawning gravels also reduce the survival of salmon eggs.

Lower Shasta River

Even the small releases from Dwinnell Reservoir (< 10 cfs) have poor water quality with warm water, low dissolved oxygen, and high nutrient loads. These releases affect the lower river downstream to Big Springs Creek. Big Springs Creek further degrades the lower river with warm water at times in the summer, but restoration efforts by the Nature Conservancy are expected to improve the conditions in Big Springs Creek and the lower Shasta River above and below the creek (Figure 4). However, even with these improvements, conditions in the lower Shasta River below Big Springs will not improve to the extent needed to provide juvenile coho over-summer rearing. It is generally agreed that more of Big Springs flow as well as improvements to the Shasta River and lower Parks Creek above Big Springs will be needed to sufficiently cool the river.

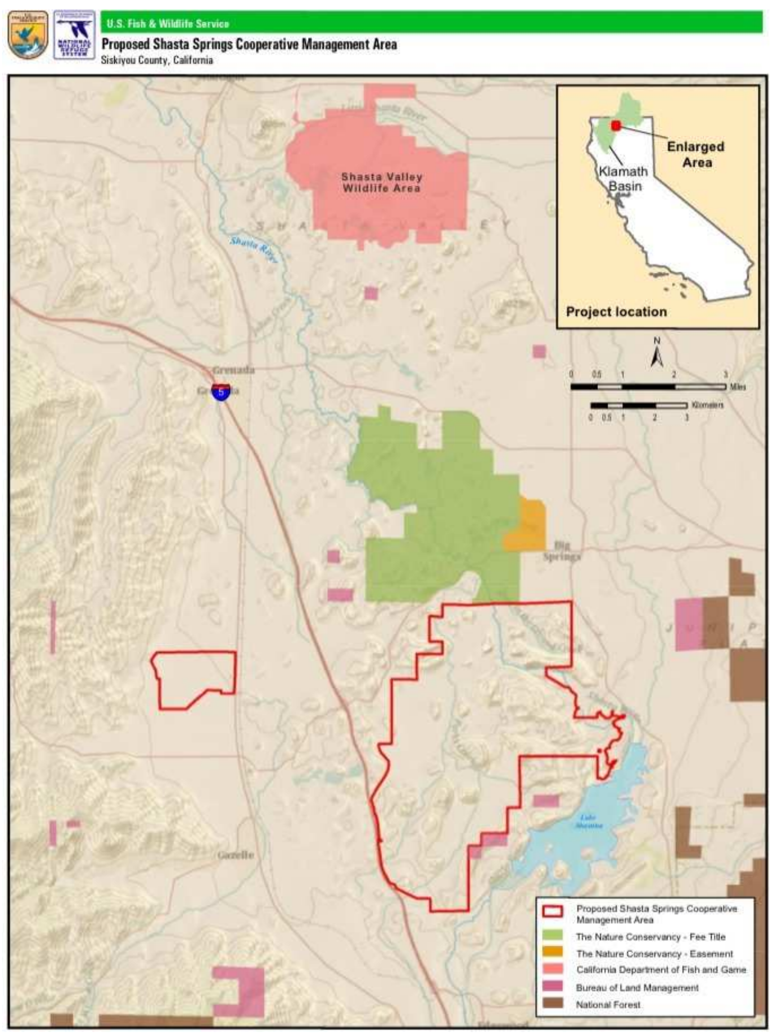

Figure 4. Lower Shasta River Cooperative Management Area

While most of the springs have cold 10-12ºC water, most of the spring flow is diverted or degraded before entering the mainstem. Even the Big Springs outlet to the river has at times been warm (>20ºC) as it enters the river. As a consequence of reduced summer flow, warm air, abundant sunlight, and warm upstream source water, the lower river in the canyon reach can reach 25ºC in summer.

Lower Parks Creek

Lower Parks Creek also contributes poor quality water to the lower Shasta River. Springs on Parks Creek have similar cold water but lower Parks Creek water temperatures are warm as well before reaching the Shasta River. Despite abundant cold clean spring resources providing water to the ranches along lower Parks Creek, water diversions and irrigation returns also have led to high water temperatures and nutrient levels in lower Parks Creek. Plans for the Lower Shasta River Cooperative Management Area (Figure 4) also call for restoring water quantity and quality in lower Parks Creek.

Upper Shasta River and Upper Parks Creek

Above the major diversions on the upper Shasta River and upper Parks Creek water quality is generally good with cold water, low suspended sediments, and low nutrients. However, below water diversions the river and creek suffer from low flows and high water temperatures. In addition, below irrigation returns there are high nutrients and low dissolved oxygen. On the Shasta River below Edgewood (RM 43) and below the Edson-Foulke diversion dam (RM 47.8; Yreka Ditch diversion), the river is warm with low flow during the irrigation season. On Parks Creek above the confluence of the MWCD diversion channel (RM 44) water quality is better than below because of the many diversions and irrigation returns below and a degraded channel and riparian shade corridor. Spring flows from Carrick, Beaughton, and Boles Creeks are cooler high-quality water, but flows are reduced and water quality degrades as they flow downstream to the upper Shasta River and Dwinnell Reservoir. Source springs to these creeks are cold (as low as 7.5ºC in summer from ice and snow melt from Mt Shasta).

Dwinnell Dam and Reservoir

Dwinnell Dam and reservoir are owned and operated by MWCD. The community of Lake Shastina surrounds the reservoir (lake) and began as recreational community in 1968. There are over 4000 home lots on 1800 acres in the community, as well as paved roads, sewers, police and fire services. There is a 27-hole golf course. The community has a waste water treatment plant that sends treated water to percolation ponds downstream of Dwinnell Dam, east of the Shasta River.

Dwinnell Dam (RM 38) and Dwinnell Reservoir (Lake Shastina) are the main features of the upper Shasta River watershed. The reservoir is approximately 2.8 square miles and 1800 surface acres, and covers approximately 3.8 miles of historic Shasta River channel. The reservoir is 1.5 miles wide at its widest with a maximum water depth when full of 65 ft and a mean depth of 22 ft. The reservoir holds approximately 50,000 acre-ft of water (only achieved on average in two of ten years). Reservoir inflow averages about 67,500 acre-ft from the Shasta River, Parks Creek, and local sources, occurring mostly in winter and spring. Releases for downstream irrigation (mainly to the MWCD Main Canal that services the east side of the lower Shasta River Valley) average about 24,000 acre-ft. Annual losses average 30,000 acre-ft to seepage and 6,000 acre-ft to evaporation (Deas and Null 2007, Null 2008).

With minimal summer-fall inflow, the reservoir stratifies with warmer water (20-25ºC) on the surface and cooler water at depth (11-12ºC). Outflow is usually some combination of these layers. High nutrients, abundant sun, and warm surface waters lead to high algae production in the reservoir and what are generally defined as eutrophic conditions. Cooler bottom waters isolated from the surface become anoxic as the dissolved oxygen is used up by decaying algae. Identified water quality problems that have lead to fish kills in the reservoir include elevated temperatures, low dissolved oxygen levels or anoxia, algae blooms, elevated ammonia, and elevated pH. Storage releases to meet water demands downstream and the resulting water level reduction can weaken the thermal regime and may result in early lake turnover and mixing during summer and early fall, causing low dissolved oxygen in surface water and downstream releases from the dam, as well as added nuisance algae production (including blue-green algae and their associated toxins) from sediment nutrients released into surface waters. Under very warm conditions, the reservoir pH can rise, which can lead to toxic levels of ammonia for fish (Vignola and Deas 2005). Such conditions can pose a direct risk to the survival of juvenile salmonids downstream and can lead to fish kills. Such kills have been common in the lake according to Vignola and Deas (2005). By November the reservoir is usually fully mixed, cooler, and thermally homogenous.

Landuses

Land uses in the watershed include wilderness and managed forestry in the upper watersheds and agriculture in the lower, valley portions of the watershed above and below Dwinnell Reservoir. Urban development occurs in the cities of Weed and Yreka, and around Dwinnell Reservoir. The Shasta Valley ranches primarily raise cattle or grow hay. The ranches produce grass hay and forage by irrigating with water diverted from the Shasta River, Parks Creek, springs, and groundwater. The surface diversions are under decreed, appropriative or riparian water rights.

Shasta River Fish Populations

The Shasta River is home to migratory Chinook and coho salmon, steelhead, and lamprey, as well as other native and non-native resident fishes. The Shasta River provides spawning, rearing, feeding, and migrating habitat to these fishes. The salmon runs have declined to low levels since Dwinnell Dam was constructed in 1928 and even more precipitous declines in recent decades. Coho salmon runs exceeded 1000 fish in the late 1950s, but now number less than 100. Chinook runs exceeded 80,000 in the 1930s, 30,000 in the 1960s, but in recent decades number less than 10,000.

Coho Salmon

The coho salmon is the only salmon species listed under either the state or federal endangered species act in the Klamath Basin. Chinook salmon have been proposed for listing in the past. Chinook are part of the Upper Klamath-Trinity Rivers ESU, which is presently not listed, but have been petitioned for listing. Coho adults migrate into the Shasta River in the late fall or early winter, usually with the first significant rains and river flow of the year in November or December. While some spawn in the lower river canyon near the Klamath River, most move upstream to the area of the Big Springs below Dwinnell Dam and in lower Parks Creek to spawn. Most spawn in early winter in lower Parks Creek, the mainstem of the Shasta River above and below Big Springs Creek, upstream to the mouth of Parks Creek, or in Big Springs Creek. Few spawn in the mainstem Shasta River between the mouth of Parks Creek and Dwinnell Dam because of low flows and a lack of spawning gravel. Spawning gravel is 1-20 cm in size (about the size of peas to oranges) that is less than 30 percent fines (<3 mm) and stable, and located within the winter low-flow boundary of the channel.

The eggs hatch in winter and fry emerge from gravel in spring. Early rearing habitat is shallow (<30 cm), quiet areas (<10 cm/s) usually associated with backwater pools, beaver ponds, and in side channels.

Young over-summer in these same habitats where water is cool (generally less than 16ºC), shaded, and protected (e.g. beaver ponds). In the lower Shasta River and lower Parks Creek such habitat is found only in isolated areas with cool spring water. Young coho must seek out these refuges to survive. Some may migrate many miles to find such habitat as waters warm in spring and early summer. They seem to have an innate ability to seek and find such refuge. Some of these spring-water refuges have been located in the lower Shasta River and lower Parks Creek. Big Springs and associated springs, Clear Spring, and Kettle Springs are notable examples, and make up the majority of over-summering habitat in the entire Shasta River.

By late fall as the water cools in the spring refuges, young coho disperse into general over-wintering habitat throughout the lower Shasta River and Parks Creek, prior to moving out to the Klamath River and ocean in late winter and spring at roughly one year of age. Rearing in warmer spring water (7ºC or higher) during the height of winter especially in deeper, slow water habitats, with abundant cover provides added growth and survival advantages that carry over into outmigration and early rearing in the ocean.

In spring, young salmon are ready to migrate to the ocean and need adequate flow for migrating to the Klamath River. They are naturally adapted to migrating on spring freshets from rainfall and snowmelt.

Fall Run Chinook Salmon

Chinook salmon are not listed under either the state or federal endangered species act in the Klamath Basin but were recently petitioned for listing and are now considered a Candidate Species[1]. Fall run adults migrate into the Shasta River in the early fall, usually as the river initially cools. While some spawn in the lower river canyon near the Klamath River, many move upstream to the area of the Big Springs Complex to spawn. Many spawn in the fall in the mainstem of the Shasta River above and below Big Springs Creek, upstream to the mouth of Parks Creek, or in Big Springs Creek. Fewer spawn in the mainstem Shasta River between Parks Creek and Dwinnell Dam because of a lack of spawning gravel or low flows. Preferred spawning gravel is larger than that for coho (about the size of oranges to grapefruit) and located within the main channel.

The eggs hatch and fry emerge from gravel in winter and early spring. Early rearing habitat is usually shallow (<30 cm), quiet areas (<10 cm/s) associated with backwater pools, stream margins, and side channels. Most newly emerged fry migrate downstream to the Klamath River and estuary, but some young over-summer in stream habitats where water is cool (generally less than 16ºC), shaded, and protected. By fall most young Chinook have left the river.

[1] Federal Register Vol. 76 No. 70. April 12, 2011 (76 FR 20302)

Spring Run Chinook Salmon

Spring run Chinook salmon were once the most abundant salmon run in the Shasta Valley, but are now extinct in much of the Klamath Basin including the Shasta River. Spring run adults migrated into the Shasta River in the late winter and spring, usually during periods of high runoff, which allowed them to ascend high in the watershed. While some probably spawned in the lower river canyon near the Klamath River many moved up to Big Springs and the river upstream of Big Springs including the upper Shasta River above the location of Dwinnell Dam and into spring creeks such as Boles, Carrick, and Beaughton, and possibly the upper Shasta River and upper Parks Creek to over-summer in deeper cold-water pools. Most spawned in early fall in or near their over-summer holding areas.

Spring run eggs hatch and fry emerge from gravel in winter. Early rearing habitat is usually shallow (<30 cm), quiet areas (<10 cm/s) associated with backwater pools, beaver ponds, and in side channels. Most newly emerged fry migrated downstream to the Klamath River and estuary, but some young over-summered in stream habitats where water was cool (generally less than 16ºC), shaded, and protected. By fall most young spring run Chinook had left the Shasta River.

Steelhead

The Steelhead is not listed under either the state or federal endangered species act in the Klamath Basin. Steelhead adults migrate into the Shasta River in the late fall or winter, usually after the first significant rains of the year. (Note: some summer-run steelhead have been observed in Big Springs). While some spawn in the lower river canyon near the Klamath River, many move upstream to the area of the Big Springs Complex below Dwinnell Dam and in lower Parks Creek to spawn. Most spawn in late winter or spring in Parks Creek and the mainstem of the Shasta River above and below Big Springs Creek, upstream to the mouth of Parks Creek, or in Big Springs Creek. Few spawn in the mainstem Shasta River between Parks Creek and Dwinnell Dam because of a lack of winter flow and spawning gravel. Spawning gravel is 1-20 cm in size (about the size of peas to oranges) that is less than 30 percent fines (<3 mm) and stable and located within the winter low-flow boundary of the channel.

The eggs hatch and fry emerge from gravel in spring or early summer. Early rearing habitat is usually shallow (<30 cm), quiet areas (<10 cm/s) usually associated with backwater pools, stream margins, and in side channels.

Young spend their first year or two in flowing stream habitats where water is cool (generally less than 20ºC), shaded, and protected. In the lower Shasta River and Parks Creek such habitat is found in areas with cooler flowing water. Some of these cool-water refuges have been located in the lower Shasta River and Parks Creek.

Lamprey

Pacific lamprey and the western brook lamprey are two of several or more species of lamprey that occur in the Klamath Basin and possibly the Shasta River. The Pacific lamprey is anadromous and was once a valuable food source of Native Americans. Reaching up to 30 inches in length lamprey once ascended the Klamath and its tributaries in large numbers to spawn. Their life cycle being much like salmon, lamprey have similar migration and habitat requirements, except young burrow into soft sediments in stream margins. Like salmon, adult lamprey also die after spawning. Lamprey spend the majority of their lives (usually 3-7 years) as larvae (ammocoetes) in freshwater before migrating to the ocean to mature. Larvae feed on algae and small insects in sediment. After the larval period they undergo metamorphosis and take on the adult form and begin to feed parasitically on fish with their suction-like mouth. The adults live at least 1-2 years in the ocean and then return to fresh water to spawn in gravel beds and then die.

Non-Native Fishes

Non-native fish occur primarily in Dwinnell Reservoir (Lake Shastina), where they have been introduced as gamefish or gamefish forage. The most abundant species are brown trout, largemouth bass, and black crappie. All three species are known predators of juvenile salmonids. Brown trout likely occur in suitable habitats of the upper Shasta River and Parks Creek.

Shasta River Fish Habitat

The Shasta River has a diversity of fish habitat from the headwaters to the confluence with the Klamath River. Key habitats are migrating, spawning, over-summering, and over-wintering habitats. The watershed’s habitat is unique in character because of Mt Shasta and it prehistoric actions that formed the Shasta River Valley. First there are the springs and snow melt to the upper glacial valleys, then the large low-gradient valley formed by a debris flow from Mt Shasta, and finally the 7-mile canyon reach where the Shasta River descends into the Klamath River canyon. The unique high-elevation, low-gradient, spring-fed hydrology, and volcanic soils form one of the more productive salmon systems in North America. The low gradient valley especially provides the right habitat ingredients for coho and Chinook salmon. The wide valley floodplain provides for multiple channels, wetlands and diverse riparian vegetation supported by an extensive spring-water network. The meandering river and floodplain environments are highly fertile, and thus also associated with widespread human resource use, including development of agriculture, urban centers, and transportation systems (I-5).

As is the case of most developed valleys, controls have been placed on the river in the valley floor including dams, dikes, levees, in-channel flow weirs for water diversions, and an elaborate system of irrigation canals and returns. Many natural habitat features including beaver ponds, river meanders, wetlands, riparian vegetation, floodplain forests, wetlands, side channels, terraces, large woody materials, and deeper stream pools have been lost to development. As a result, the spawning, rearing, and migrating habitat of salmon and steelhead has been greatly altered in the basin. Dwinnell Dam and Reservoir have essentially separated the upper and lower watersheds and eliminated the upper watershed for salmon use. Changes in flow, water quality, and sediment, along with the physical ramifications of development (agriculture, urbanization, forestry, roads, dams, impervious surfaces, etc) have all degraded habitats to varying degrees throughout the watershed.

Canyon Reach of Lower Shasta River

The lower-most river reach is that portion that descends through the 7-mile canyon to the Klamath River. With reduced sediment and stream flow the lower river has incised and its bed material increased in size with the steepening channel gradient. With limited shade it warms in summer to levels that cannot support salmon. Reduced flow from water diversions plus irrigation returns contribute to warming. High organic loading and warm water reduce dissolved oxygen levels in summer. Reduced flows and blockage of sediment at upstream dams contributes to coarsening of the bed material, thus severely limiting salmon spawning habitat. Past restoration efforts have increased the supply of spawning gravels to the reach and it thus remains important for spawning of salmon and steelhead.

Lower Shasta Valley

The lower valley is that 20-mile zone below the Big Springs Complex to the lower end of the valley above the canyon reach. Flows, water quality, and stream habitat in the lower Valley have been greatly altered from agricultural development. Changes in streamflow, sediment transport, and riparian vegetation have led to major degradation of the river channel and the riparian floodplain. The river is wider, shallower, straighter, and warmer, with less riparian vegetation and gravel, and more sand and silt.

Middle Shasta Valley

The Nelson Ranch, Big Springs Complex, lower Shasta River below Dwinnell Dam, and lower Parks Creek (below I-5) represent 10-miles of the middle Shasta River Valley habitats. Much of the salmon spawning and rearing occurs in the area, especially that of coho salmon, however the amount of habitat is limited because of Dwinnell Dam and its effects on water flow and quality, and on natural sediment transport from the upper watershed. The Nature Conservancy has purchased Nelson Ranch and Big Springs Ranch, the lower portion of this area (Figure 4), and is undertaking major habitat restoration to improve habitat. In the upper portion above the Big Springs Complex, consisting mostly of the Emmerson Ranches (Figure 4), there is also extensive restoration planned and partially underway (mainly riparian fencing).

Upper Shasta River

The upper 20 miles of the Shasta River including and upstream of Dwinnell Reservoir and 20 miles of upper Parks Creek (above I-5) are heavily degraded by development especially agricultural water and land use. Most of the water in the upper Shasta River, its tributaries, and upper Parks Creek is diverted for agriculture and municipal use. Dwinnell Dam and reservoir are the dominant features in the upper watershed. Their presence essentially separates the upper watershed from the lower river valley, and eliminates the upper river’s habitats from use by salmon and steelhead. Despite the apparent degradation in the upper watershed many key habitat attributes such as spawning gravels, riparian vegetation, stream channels, and headwater forest watersheds are in relatively good shape and readily restorable.

Upper Shasta River Restoration

Restoration of the Upper Shasta River for salmon and steelhead would require removing Dwinnell Dam, providing fish passage at the dam, or constructing a dam/reservoir bypass, as well as restoration of upper watershed habitat to accommodate salmon and steelhead. Estimates indicate that approximately 20 percent of the available salmon and steelhead spawning habitat of the Shasta River is in the upper watershed. With restoration that percentage could be even higher.

Alternative 1 - Removal of Dwinnell Dam and Reservoir

Removal of Dwinnell Dam (Figure 5), a large earthen dam, would be a relatively straight forward engineering project, although costly proposition. Recent similar removal projects in Washington State at the Condit and Elwha dams involved essentially notching openings in the dams and allowing the one-time release of remnant water (after draining) and associated large amounts of silt, sands, and gravels from the bottom of the reservoirs. Dam remnants and reservoir sediments would be stabilized as much as possible, but long-term erosion of these elements would occur perhaps for decades.

In addition to the costs of engineering and long-term maintenance at the site, additional costs would likely be associated with other reservoir facilities, homeowners, recreational resources, and storage water rights owners.

Figure 5. Dwinnell Dam and Reservoir looking north from south shoreline.

Another substantial cost of dam removal is restoration of the habitat within the reservoir reach of nearly four miles. With nearly 80 years of operation, the reservoir has substantially filled with sediment. Allowing sediment to erode and move downstream would have substantial long term downstream effects especially given the relatively low winter-spring flows of the upper Shasta River watershed that would be relied upon to carry the sediment to the Klamath River. In any event, a full evaluation of dam removal would require an analysis of the volume and toxicity of sediments, a sediment transport analysis, and flood risk analysis. If studies indicate that dam removal must be preceded by dredging large amounts of sediment, the cost of removal would increase significantly.

The low warm summer flows of the upper Shasta River entering the reservoir reach would be further degraded by an open river channel in the reservoir reach. Restoration of the channel and riparian corridor would be necessary to provide anticipated benefits. A substantial portion of the cold spring water from Carrick, Boles, and Beaughton Creeks would also have to be restored to provide anticipated flow and water quality benefits of dam removal. The Shasta River upstream of the reservoir reach for four miles to the mouth of Beaughton Creek would also require restoration of the channel, floodplain, and riparian corridor.

With these improvements under dam removal substantial habitat improvements could be expected within the reservoir reach (four miles), the Shasta River above the reservoir reach (four miles), and the reach of the lower Shasta River below the dam downstream through the lower Shasta River past the mouth of Parks Creek (six miles), Big Springs Creek, and on into the lower Shasta River.

In total with Dam Removal, fish passage would be provided to the 14 to 16 miles of the potential anadromous reach of the Shasta River and dozens of miles of tributaries including Carrick, Beaughton, Boles, Dale, and Eddy creeks above the reservoir. However, substantial improvements of stream flows, fish passage, and habitat would be required to accommodate migrating salmon and steelhead to this newly accessible habitat. More discussion of potential habitat improvements to the upper watershed follows in a later section.

Alternative 2 - Fish Passage Facilities at the Dam

An alternative to dam removal would be to provide a fish ladder at the dam or to trap and haul salmon around the dam or reservoir. A fish ladder could be constructed at the dam that would allow adult salmon and steelhead to ascend over the dam to the upper river to spawn. Although ladders are costly, they generally are very successful passing adult salmon and steelhead. In addition to the water needed for the ladder there is also a need to provide attraction flows to the lower Shasta River to attract fish to the ladder. Such flows would be necessary in all months, with the possible exception of summer. Also, as in the dam removal alternative, substantial improvements to the upper watershed would be necessary to accommodate salmon and steelhead.

There are some serious drawbacks to employing a ladder at Dwinnell Dam. First, is the associated cost of building a ladder at an earthen dam, especially to an irrigation reservoir that has highly variable water storage and water surface elevations during the year and between years. Second, water quality especially temperature will be a problem for migrating fish from late spring through early fall in the reaches below, within, and above the reservoir, as well as in the ladder. Third, and perhaps most important, is getting the juvenile fish to pass successfully downstream through the reservoir and dam to the lower river. Conditions in the reservoir are poor for much of the year, except possibly in winter. Even for winter passage substantial flow would have to be released to the river below to effectively pass juvenile fish downstream through the lower outlet, spillway, or ladder. There are effective means of directing downstream migrating juvenile fish through the reservoir to the dam outlets, but these have substantial capital and maintenance costs. Lastly, there are substantial non-native predatory fish in the reservoir that would prey upon young salmonids passing through the reservoir.

In addition to or in lieu of a ladder, adult and juvenile salmon and steelhead could be trapped and hauled around the reservoir to and from the upper watershed. Generally, adult salmon and steelhead can be effectively trapped on their upstream migration and trucked to the upper watershed. Some added stress, mortality, or loss in condition can be expected in trucked adult fish. Trapping juvenile fish before they return to the reservoir is more difficult, as often they migrate downstream during high winter-spring flows. However, high flows are relatively rare in the upper Shasta River and at such times it may be possible to allow the juvenile fish to pass through the reservoir to the lower outlet, spillway, or ladder. Trapping the juvenile fish above the reservoir would eliminate potential predation by non-native fish in the reservoir. As in the case of the ladder, the upper watershed would need to be restored to a certain extent to accommodate salmon and steelhead migrating, holding, spawning, and rearing.

Alternative 3 - Bypass

Passage of salmon and steelhead to the upper Shasta River watershed can also be provided by constructing a bypass around Dwinnell Dam and reservoir. Such a system was proposed by Potlech (2009) in a report to MWCD as an alternative to dam removal. The bypass concept is relatively simple – there are three relatively easy routes for passing water from the upper Shasta River to Parks Creek that have low gradients that would allow salmon and steelhead to migrate upstream into the upper Shasta River via Parks Creek (Figure 6). One or all three could be constructed to provide a bypass via lower Parks Creek. Such a bypass would allow Dwinnell Reservoir to operate essentially as an off-stream storage reservoir. Combined, the three bypass routes offer substantial stream flow capacity that would include all the major upper watershed tributaries except for Carrick Creek that flows directly into Dwinnell Reservoir. The lower two connections would allow the capture of flows from (and salmon access to) Beaughton and Boles Creeks, the two major upper spring-fed cold-water tributaries with substantial water supplies from Mt Shasta springs. Potlech (2009) proposed the connection at Site B in Figure 6. Sites B and A bypasses would pass through existing I-5 underpasses.

The upper-most bypass at Site E would take advantage of the existing Yreka Ditch and its diversion on the upper Shasta River, the Edson-Foulke diversion at RM 47.8. The diversion dam on the Shasta River and the siphon on Parks Creek could be retrofitted to allow flow and fish passage, as well as provide improved habitat in upper Yreka Ditch (between Shasta River and Parks Creek). Some accommodation for water delivery to lower Yreka Ditch would also be necessary.

The Bypass concept allows considerable plumbing options to accommodate the overall objectives. The existing diversion from Parks Creek at Site C could be retained to route flows from Parks Creek to Site A. There would be no need to screen Site C (as presently planned), instead Site A would need to be screened to ensure young fish do not pass to Dwinnell Reservoir. All of the reaches including the three bypasses could be sustained as viable spawning and rearing habitats if sufficient water supplies are available, although the concept would require substantial changes to current water management practices. It may also be possible to appropriate additional water supplies for the concept (e.g., from NF of the Sacramento River). Additional screening and fish passage facilities as well as substantial habitat improvement would also be necessary.

Depending on available water, the Bypass flow into lower Parks Creek could be substantial at 20-60 cfs from early fall through late spring, or even higher during flood flows. In addition to providing a route of passage for adult and juvenile salmon and steelhead there could be substantial benefits to the lower river including high quality water as well as gravel transport. Sediment transport could possibly be restored to the lower river by allowing high Parks Creek – upper Shasta River flow pulses to pass downstream via lower Parks Creek to the lower Shasta River, potentially providing at least some gravel transport. Some channel restoration in lower Parks Creek may be needed to allow for this benefit.

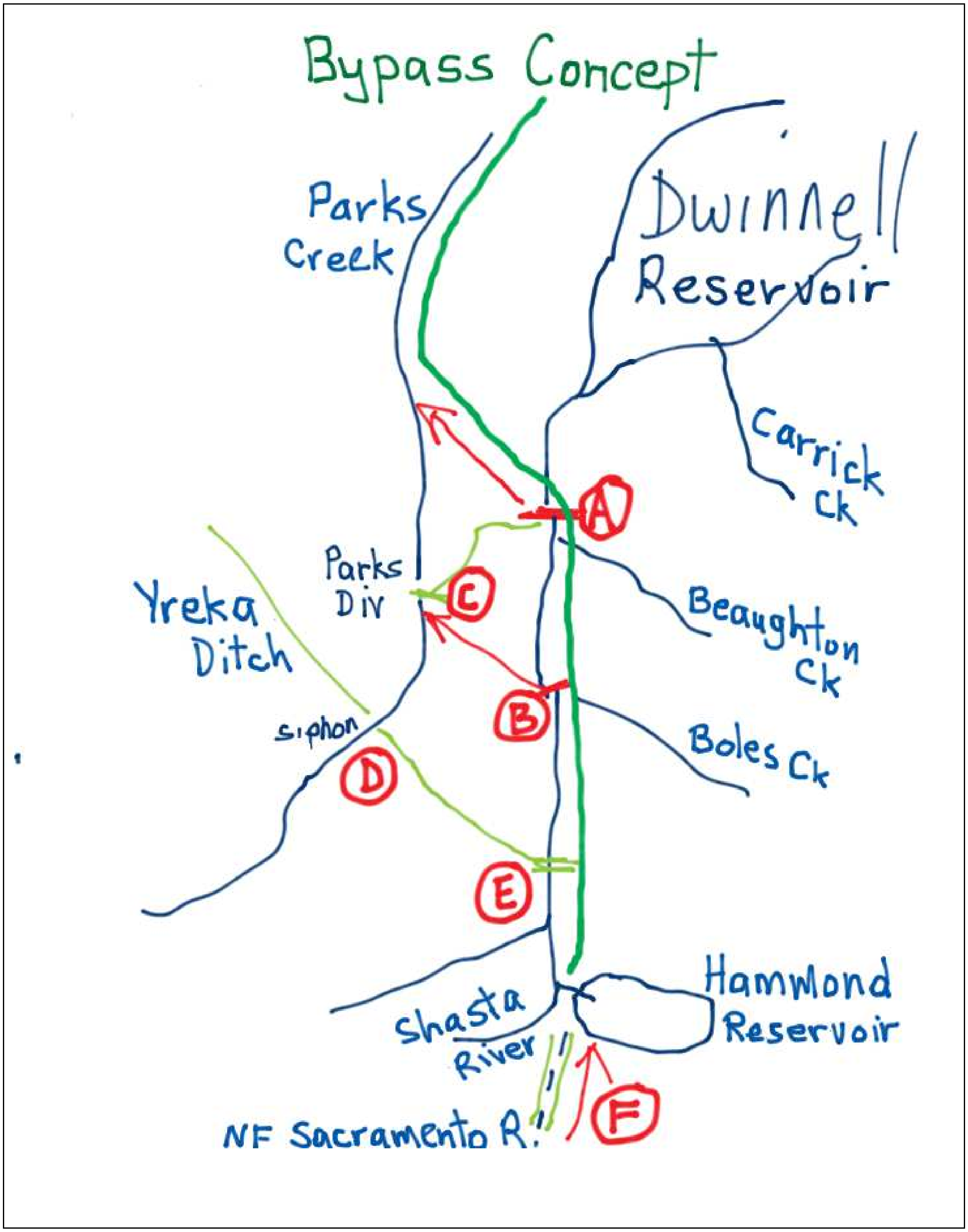

Figure 6. Bypass concept. There are three potential connections between Parks Creek and the upper Shasta River (A, B, and E). The existing diversion to the Yreka Ditch from the upper Shasta River at E can be connected to Parks Creek at D. Low gradient bypasses can also be constructed at A and B that would pass under I-5 via existing underpasses. Additional flow can also be obtained from the upper Sacramento River at F via Eight Mile Ditch.

Habitat Restoration

Providing access for salmon and steelhead to the upper Shasta River will require substantial habitat restoration to accommodate the needs of the fish. There would be some minimum degree of restoration as well as potential higher levels of restoration that may be achievable. No attempt has been made in this report to separate these two levels, only to describe the array of possibilities and potential benefits.

Water Supply Improvements to Shasta River above Big Springs

The most critical habitat restoration element is water supply for stream flow. Various reports and studies have roughly estimated the existing and potentially available summer and winter base flows of the upper Shasta River and Parks Creek above Big Springs (RM 34) that would or could be available if the dam were removed or a bypass constructed as described above. Summer baseflow is the most critical habitat factor as it is most limiting. Winter base flows are generally higher as they incorporate water that is otherwise diverted in irrigation season plus there is less evaporation and riparian plant evapotranspiration.

Summer base flows in the lower Shasta River above Big Springs are approximately 40-60 cfs under varying degrees of irrigation diversions, inflow from springs, dam and reservoir leakage, and irrigation return flows. About 10 cfs is generally released from Dwinnell Dam. About 15-20 cfs enters the Shasta River below Dwinnell via various springs (including reservoir leakage). Another 10-20 cfs enters via irrigation returns. About 5-10 cfs enters from lower Parks Creek springs and irrigation returns (Parks Creek is generally dry at I-5 underpass).

Winter base flows below Dwinnell Dam above Big Springs increase to 80-150 cfs as diversions decrease, spring usage declines, and plant evapo-transpiration declines. Flow increases from upper Parks Creek are included as diversions decrease in that subwatershed.

Above Dwinnell Dam and reservoir and in upper Parks Creek the water supply is highly variable and heavily used for irrigation and municipal uses. In summer, only about 10 cfs reaches Dwinnell Reservoir as most of the water supply is used for irrigation. However, the potential water supply from springs is substantial (Carrick – 10 cfs; Beaughton – 10+cfs; Boles – 10+cfs). Flows from upper Shasta River (including Dale and Eddy Creeks, and Hammond Reservoir) could be an additional 10 cfs. Flows from upper Parks Creek may be a further 10 cfs. The total potential base flow to the Shasta River under the Dam Removal Alternative is on the order of 40+cfs (not including Parks Creek). For the Bypass Alternative (not including Carrick Creek) the total is also approximately 40+cfs. Either alternative thus could contribute an additional 40+cfs to the 40-60 cfs summer base flow of the lower Shasta River, but not without a substantial reduction in the irrigation water supply to the upper watershed and Dwinnell Reservoir. Winter base flows as stated earlier are substantially higher than summer base flows. Additional water supply could be developed from the North Fork Sacramento River to the upper Shasta River via Eight Mile Ditch. Under the Bypass Alternative some of the water supply could be released from Dwinnell Reservoir to benefit habitat in the lower Shasta River reach between Dwinnell Dam downstream to the mouth of Parks Creek.

Stream Habitat Improvements to Shasta River above Big Springs

Under either the Dam Removal or Bypass Alternatives stream habitat should be enhanced to accommodate salmon and steelhead spawning, holding, rearing, and migrating. Spawning habitat in the upper Shasta River and upper Parks Creek could be extensively restored with the existing abundance of substrate materials. The stream channels are braided with pools, bars, undercut banks, meanders, and scattered riparian vegetation. Restoration would involve adding large woody materials to diversify habitat and enhancing riparian vegetation. Eliminating or screening water diversions would limit loss of juvenile salmon and steelhead.

Under the Dam Removal Alternative, stream habitat would need to be extensively restored from the dam site upstream to near Edgewood, approximately 8 miles. Some restoration may also be necessary in the six miles below the dam site to accommodate the new water and sediment supply. Four to six miles of Carrick Creek would be accessible to salmon and would need to be restored. Restoration of lower Parks Creek should be considered as it is now and could remain a major spawning reach for coho salmon. Such restoration could involve rehabilitating springs (e.g., Kettle Spring and its creek) and the lower Parks Creek channel. Assuming the upper Parks Creek diversion would no longer be needed, considerable flow and sediment transport would resume in lower Parks Creek. However, if other means are allowed for continuation of this water right and diversion at the dam site, some provision for flow and sediment transport below the MWCD diversion would be necessary to help sustain and restore lower Parks Creek.

With the Bypass Alternative, stream habitat would need to be created or restored in the new bypass channels, Parks Creek, and Upper Shasta River. Some restoration will be needed in lower Parks Creek from I-5 downstream to the mouth to accommodate the new stream flows and sediment transport, as well as improve spawning and rearing habitat in the reach. The MWCD diversion from Parks Creek to the Shasta River could be effectively restored as habitat and used to convey high flows for possible storage in Dwinnell Reservoir. At the lower-most bypass diversion dam the bypass of flow to Dwinnell Reservoir would need to be screened to ensure juvenile salmon do not move to the reservoir.

In either alternative, restoration of Boles and Beaughton Creeks, upper Parks Creek, and the upper Shasta River including Dale and Eddy Creeks would be necessary. Diversions would have to be removed or screened and spawning and rearing habitat rehabilitated. Passage barriers would have to be fixed or removed. Approximately 9 to 13 miles of the mainstem Shasta River plus many miles of tributary creeks and upper Parks River above Dwinnell Dam would require some restoration to accommodate salmon and steelhead. Beaughton Creek alone has 4 to 6 miles of suitable accessible habitat. Boles Creek has an additional 2 to 4 miles of habitat. Most of the upper Shasta River valley is under agricultural use and would require considerable exclusionary fencing and restoration. Various SVRCD reports describe the upper watershed habitat and outline some of the potential restoration needed.

Eddy and Dale Creeks, along with the upper Shasta River above RM 48 would have more than four miles of accessible and highly suitable habitat for salmon and steelhead, and would require water supply and habitat restoration. The coarse sediment supply, especially of spawning gravel, from this reach would be essential for spawning habitat throughout the upper Shasta River and bypasses. Stream flow in this reach could be supplemented with flows from Hammond

Reservoir and the North Fork of the Sacramento River via Eight Mile Ditch (Figure 7). The existing North Fork water right (held by Hammond Reservoir Irrigation Association) is 190 days at 15 cfs maximum diversion (ditch capacity); however, generally less is diverted because of the limited North Fork water supply.

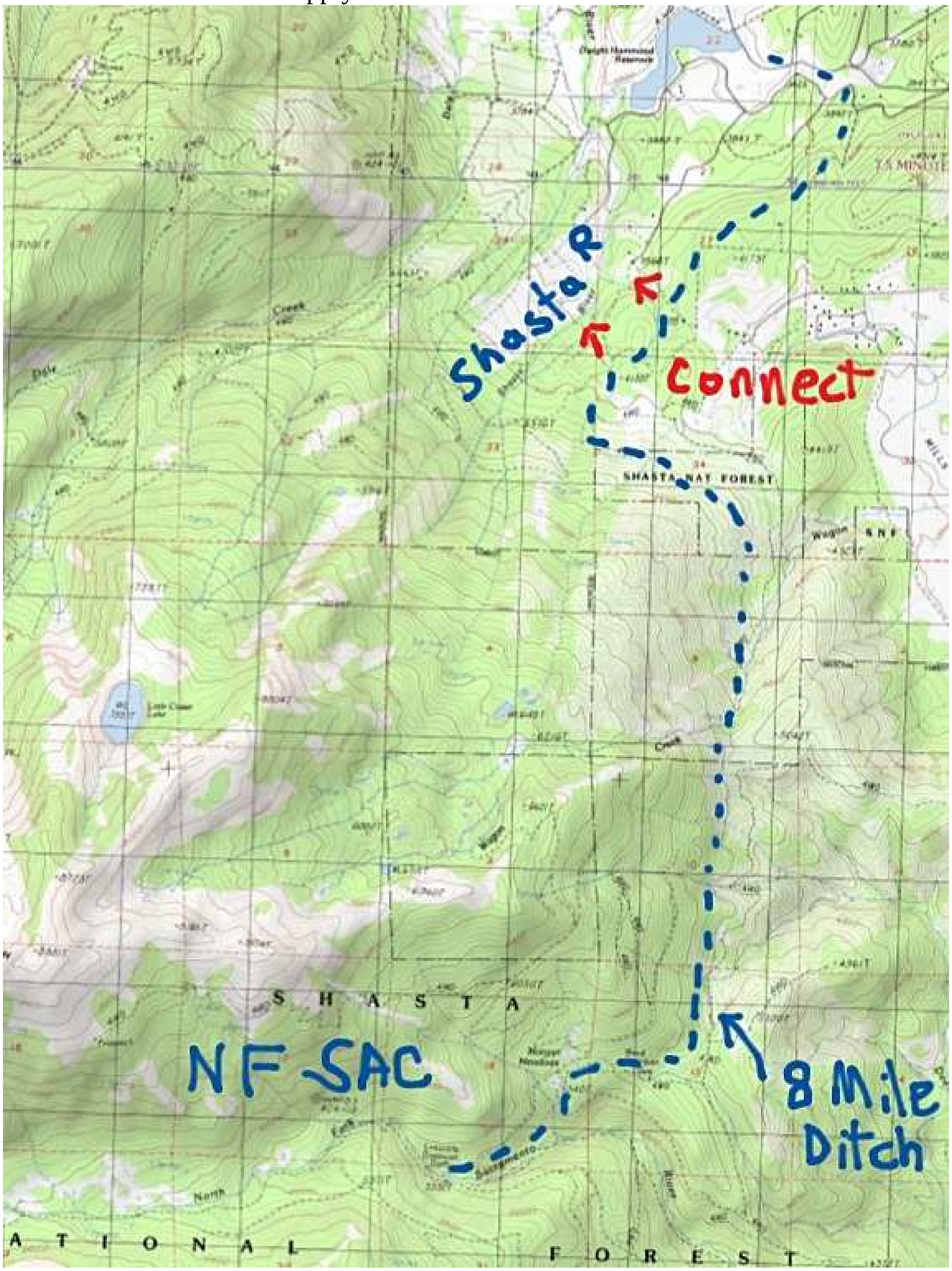

Figure 7. Upper Shasta River watershed and water diversion from North Fork Sacramento River. Connections indicated could release water to upper Shasta River.

Comparison of Alternatives

The following tables compare the four alternatives in terms of potential benefits, cost, and schedule, plus specific notes on main points of difference.

Table 1. Potential benefits of Dam Removal, Ladder, Trap-Haul, and Bypass alternatives

	Removal	Ladder	T&H	Bypass
Passage	High[1]	Moderate	Moderate	High
Habitat	High[2]	Low	Low	Moderate
Flow	High	Low	Low	High[3]
Water Qual	High	Low	Low	High
Coho	High	Moderate	Moderate	High
Spring Run	High	Moderate	Moderate	High
Fall Run	High	Moderate	Moderate	High
Steelhead	High	Moderate	Moderate	High

Table 2. Costs in terms of dollars and time of Dam Removal, Ladder, and Bypass alternatives

	Removal	Ladder	T&H	Bypass
Cost	High[4]	High	Moderate	Moderate
Schedule	Long[5]	Long	Intermediate	Intermediate

1. The Dam Removal Alternative provides passage in the natural Shasta River and Parks Creek channels, whereas the Bypass Alternative focuses passage only via Parks Creek and artificial bypasses.
2. The Dam Removal Alternative potentially provides substantial added or improved habitat area that is not included in Bypass Alternative. From the Bypass location to at least mouth of Parks Creek there are 12-14 added miles of additional or better habitat than the Bypass Alternative. Habitat in the Shasta River below Dwinnell Dam to mouth of Parks Creek would be much improved in Dam Removal Alternative, and less so in Bypass Alternative. Sediment transport, especially of spawning gravels, to the lower Shasta

River would be more effective under Dam Removal Alternative. Benefits to lower Parks Creek could be high for both alternatives, but would be less costly and probably more substantial with the Bypass Alternative.

3. The Bypass Alternative allows for off-stream storage that could potentially be used in periods of drought for lower Shasta River flow. Retaining the reservoir also offers water supply management flexibility that could benefit lower river salmon and steelhead habitat and irrigation management flexibility. Cold water storage in the hypolimnion of reservoir could be managed more effectively with additional structural facilities.
4. Costs are high because of dam removal, irrigation infrastructure, and anticipated socioeconomic mitigation. For example, a new diversion at the dam site may be required at the dam site to accommodate irrigation diversions to the MWCD Main Canal.
5. Many of the elements of the Dam Removal Alternative would take considerable time to implement or to realize their full potential; whereas, some key aspects of Bypass Alternative could be implemented in a shorter amount of time.

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Attachment - Selected Photos

Upper Shasta River near Edgewood

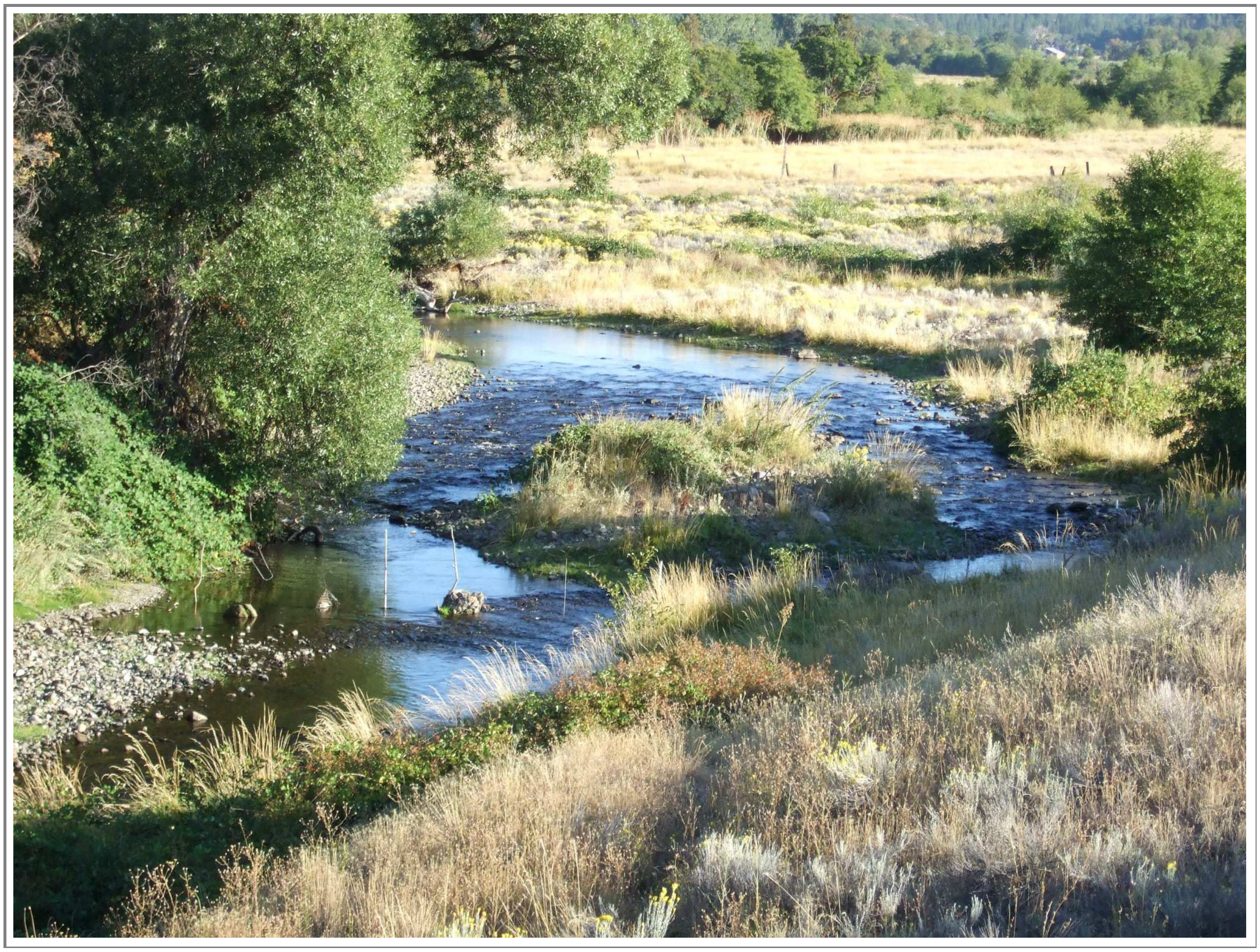

Figure 5. Upper Shasta River at Old Stage Road crossing, just downstream from the confluence of Dale Creek and Eddy Creek, approximately 7.5 miles upstream of Lake Shastina. Photograph shows a gravel, cobble, and boulder channel. View facing downstream, photo taken 10-11-2009.

Upper Shasta River (Source: SVRCD 2010)


Shasta River below Dwinnell Dam.


Shasta River immediately below Dwinnell Dam.

Beaver dam on Shasta River below Dwinnell Dam.

Parks Creek - Railroad bridge over Creek. Watermaster Joe Scott on 4-wheeler. Photograph taken on 20100616.

Parks Creek – Looking from downstream of railroad bridge to east side of creek. Photo 1 of 4 of a panorama. Photograph taken on 20100616.

Parks Creek below MWCD diversion. (Source: water master)

Parks Creek Diversion 183 – Looking down the Yreka Ditch from the siphon outlet.
Photograph taken on 20100616.

Yreka Ditch at upper Parks Creek. (Source: water master)

Headworks of MWCD Parks Creek diversion. (Source: water master)

MWCD diversion canal from Parks Creek to upper Shasta River at Parks Creek. (Source: water master)

Photo 4. Diversion dam at RM 46.3

Photo 6. Diversion dam at RM 47.8

Upper Shasta River diversions. (Source: Potletch 2009)

Photo 7. Beaughton Creek at RM 0.1

Photo 8. Beaughton Creek at RM 0.1

Photo 9. Beaughton Creek at RM 3.5

Photo 10. Beaughton Creek at RM 4.0

Photo 11. Boles Creek at RM 0.5

Photo 12. Boles Creek at RM 0.5

Beaughton and Boles Creeks. (Source: Potletch 2009)