

Battle Creek Salmon and Steelhead Restoration Plan



Prepared for the

Battle Creek Working Group

by

Kier Associates
Sausalito, California

January 1999

Cover Photo

Cold spring water flows from moss- and fern-draped cliffs in Eagle Canyon on North Fork Battle Creek. Unique volcanic processes within the Battle Creek watershed have given rise to many cold springs which insulate fish from the hot weather of the Central Valley and have created dramatic gorges which protect fish from casual contact with people. The geologic features of the Battle Creek watershed are unequalled among California's many natural treasures and have guided the evolution of biologically unique populations of salmon and steelhead that will once again thrive in a restored Battle Creek watershed.

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by

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EXECUTIVE SUMMARY

This Battle Creek Salmon and Steelhead Restoration Plan (Restoration Plan) was prepared under the supervision of the Battle Creek Working Group (BCWG) by Kier Associates of Sausalito, California. The BCWG, made up of land-, water-, and fish-interested stakeholders and the State and federal agencies responsible for fish conservation, organized itself in early 1997 specifically to identify and accelerate salmon and steelhead restoration opportunities in the Battle Creek watershed, a major tributary of the Sacramento River in northern California (Figure 1).

Because of its volcanic origin and year-round, cold, and plentiful streamflows, Battle Creek represents a critical opportunity for restoring stream habitats like those of the upper Sacramento River that were blocked by the construction of Shasta Dam in the 1940s. Such coldwater streams and rivers have historically provided habitat for winter-run and spring-run chinook salmon. The winter run are now listed as endangered under the federal Endangered Species Act and spring run are listed as threatened under California's Endangered Species Act.

Battle Creek's stream habitats have been severely degraded, beginning with the development of hydroelectric and agricultural diversions in the late nineteenth century. The Coleman National Fish Hatchery (CNFH) barrier dam, which straddles lower Battle Creek, has been operated over the years, in part, to prevent the migration of salmon and steelhead into the upper watershed, lest fishborne diseases be carried back downstream into the hatchery's water supply.

The Restoration Plan describes the Battle Creek watershed and the historical roles that it has served, particularly in the development of hydroelectric power and fish culture. It describes several predecessor salmon restoration plans for Battle Creek which produced only modest results, due to the lack of sufficient habitat information and restoration funding.

Armed now, however, with a comprehensive assessment of Battle Creek fish habitat commissioned by the California Department of Fish & Game in the late 1980s and completed by the BCWG's own consultants, and with the prospect of funding reasonably assured through robust present-day Central Valley salmon and ecosystem restoration programs, the Restoration Plan focuses on 42.4 miles of the mainstem, north, and south forks of the stream above the CNFH and presents the flow and temperature conditions needed in each reach to assure the restoration of self-sustaining populations of salmon – winter-, spring-, fall- and late-fall-runs of chinook salmon – and steelhead. The Restoration Plan's prescriptions are based, in part, on principles that the responsible State and federal resources agencies consider essential for salmon and steelhead restoration in Battle Creek (see Table 9 for these principles).

Because the Restoration Plan contemplates a substantial reallocation of streamflow away from hydroelectric production – in some cases the wholesale removal of hydroelectric structures – it takes special care to spell out the steps taken to assign species priorities (e.g., winter-run chinook salmon) to each stream reach; to determine the factors of greatest concern (e.g., upstream migration, spawning, or egg incubation) for the successful production of each priority species in each target reach; and to define the streamflow and temperature parameters that will be

needed to serve each priority species and target reach and to resolve each production-limiting factor.

Finally, the Restoration Plan sets out those physical actions, and monitoring and evaluation measures, that will be necessary to achieve and sustain the restoration of salmon and steelhead in the Battle Creek, including those involving the uplands and headwaters portions of the watershed. Actions involving the integration of CNFH operations with the watershed restoration program, including changes in the operation of the hatchery barrier dam, were being addressed by the BCWG as this Restoration Plan was nearing completion. In addition, a finer-grained analysis of upland and headwater conditions and restoration needs will be completed by the watershed's landowners in 1999.

The Restoration Plan, then, provides the essential biological criteria and information upon which negotiations between the State and federal resource agencies and the Pacific Gas & Electric Company, owners of the Battle Creek hydroelectric system, are based. These negotiations began in earnest in late 1998 to establish the cost, engineering, and reimbursement basis of the restoration actions advanced in this Restoration Plan. Implementation of the salmon and steelhead restoration measures advanced in the Restoration Plan are anticipated to begin as early as 1999.

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FOREWORD

Battle Creek, which enters the Sacramento River between Redding and Red Bluff, California, has been heavily developed for hydroelectric generation, beginning as early as 1899 (Figure 1). Because it is carved into Mt. Lassen's ancient lava flow, Battle Creek could be dammed and diverted and, within yards or scant miles below nearly each such diversion, the stream's channel would refill with icy water from the watershed's porous substrate. These abundant Battle Creek flows have inspired a system of dams, tunnels, canals, and powerhouses, now operated by the Pacific Gas and Electric Company (PG&E), that literally lace the watershed as it descends from mountain meadows to the floor of the Sacramento Valley.

Battle Creek, among other habitats in the Central Valley, was once home to the region's salmon and steelhead. Populations of winter run, spring-run, fall-run, and late-fall-run chinook salmon, and steelhead have declined dramatically in recent years, so much so they were listed or are considered for listing under the provisions of the federal Endangered Species Act (ESA). Little now remains of the historic habitat for these fish; even that present within Battle Creek is degraded primarily due to a lack of instream flow.

Californians are seeking every opportunity to restore their Central Valley salmon and steelhead legacy. Beginning in 1987, the California Department of Fish and Game (CDFG) undertook a thorough evaluation of Battle Creek's salmon and steelhead habitat restoration potential. In a partnership with fisheries and water agencies, PG&E began in 1995 to increase streamflow releases from its lower dams on both forks of Battle Creek to restore the fish habitat below them. In the years since, PG&E, CDFG, the U.S. Fish and Wildlife Service (USFWS) and the California Department of Water Resources (CDWR) have investigated additional opportunities for opening up the Battle Creek watershed to all four Central Valley chinook salmon species and steelhead.

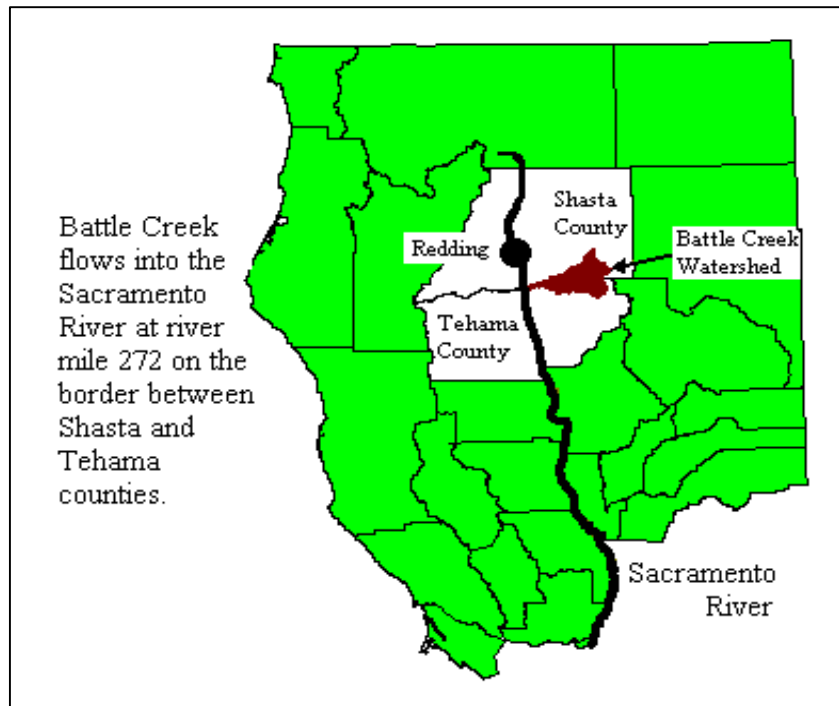
In 1997, inspired by the availability of substantial amounts of fish and wildlife restoration funds from the 1992 Central Valley Project Improvement Act (CVPIA), a 1994 San Francisco Bay-Delta Accord, a 1996 State water resources and ecosystem restoration bond act, plus the pledge of further matching funds from Congress, a stakeholder-based Battle Creek Working Group (BCWG) was formed to accelerate salmon and steelhead restoration in the watershed (Table 1). Soon thereafter, Kier Associates, consultants in watershed and fisheries restoration, were hired with funds from the 1994 Bay-Delta Accord, to pull CDFG's Battle Creek habitat assessment data and the additional new information concerning measures to restore salmon and steelhead habitat in Battle Creek into a plan.

This Battle Creek Salmon and Steelhead Restoration Plan (Restoration Plan), and the accompanying KRIS/Battle Creek data management system, developed in close consultation with CDFG, PG&E, USFWS, and the BCWG, gathers and interprets the key information needed to guide the restoration of salmon and steelhead habitat in the Battle Creek watershed to meet goals established in the Anadromous Fishery Restoration Program of the CVPIA and support other endeavors such as the Bay-Delta Accord.

Table 1. A partial list of member organizations and agencies that comprised the Battle Creek Working Group and acronyms used in this report.

Battle Creek Watershed Conservancy (BCWC)
Battle Creek Watershed Project (BCWP)
California Department of Fish and Game (CDFG)
California Department of Water Resources (CDWR)
Central Valley Project Water Association (CVPWA)
United States Forest Service - Lassen National Forest (USFS - LNF)
Mount Lassen Trout Farms (MLTF)
Metropolitan Water District of Southern California (MWDSC)
National Marine Fisheries Service (NMFS)
Pacific Coast Federation of Fishermen's Assn. (PCFFA)
Pacific Gas and Electric Company (PG&E)
Tehama County Resource Conservation District (TCRCD)
The Nature Conservancy (TNC)
United States Bureau of Land Management (BLM)
United States Bureau of Reclamation (USBR)
United States Fish and Wildlife Service (USFWS)
Western Area Power Administration (WAPA)
Western Shasta Resource Conservation District (WSRCD)

Figure 1. The location of the Battle Creek watershed in relation to the counties of Northern California.



FOUNDATION FOR RESTORATION

This document is divided into three major sections. This “Foundation for Restoration” includes subsections on geology and hydrology, anadromous fish populations, resident fish populations, selected stream-dependent plants and animals, history of the Battle Creek watershed, summary of past fisheries restoration efforts, and an overview of contemporary restoration efforts. The “Technical Plan” builds on the “Foundation” by discussing existing conditions, limiting factors, ecosystem functions, economics, and restoration objectives for each of 5 key portions of the Battle Creek watershed. Specific restoration actions are considered. Finally, the last section details “Recommendations” for the restoration of aquatic ecosystems in Battle Creek.

Geology and Hydrology

Battle Creek drains the southern Cascade Range in the northern Central Valley and flows into the Sacramento River at river mile 272, approximately 2 miles east of the town of Cottonwood, California (Figure 1). Battle Creek is comprised of two main branches, the North Fork (approx. 29.5 miles in length from headwaters to confluence) and the South Fork (approximately 28 miles in length from headwaters to confluence), the mainstem valley reach (approximately 15.2 miles from the confluence of the North and South forks to the Sacramento River), and numerous tributaries. The upper 16 miles of the North Fork and the upper 10 miles of the South Fork are not accessible to anadromous salmon and steelhead due to natural barriers¹ which impede fish migration.

The geology and hydrology of Battle Creek is unique among the tributaries to the upper Sacramento River downstream of Shasta Dam but quite similar to tributaries upstream of Shasta Dam. Battle Creek has the largest baseflow or dry-season flow of any of the tributaries to the Sacramento River between the Feather River and Keswick Dam on the Sacramento River. The spring-fed nature of Battle Creek ensures that an average September flow of 255 cfs reaches the Sacramento River from the 356 square mile drainage area. (Figure 2; USGS 1995). The creek and its tributaries drain the volcanic slopes of Mt. Lassen located at the top and center of the watershed (NPS circa 1998). The large snowfields on this 10,000 foot peak maintain stream flow until late in the summer. The volcanic formations and ancient stream channels buried by lava flows store a portion of the wet season runoff and convey it to the streams in the dry season via numerous cold springs (USGS 1956; NPS circa 1998; CDM n.d.; California Mines and Geology

¹ Physical, thermal, and chemical obstructions to fish migration are known as barriers. Barriers may completely block the upstream migration of fish, and, therefore, determine the distribution of fish within a watershed, or they may be partial barriers that either slow upstream migration or impede it for specific periods of time. The obstruction of fish migration at physical barriers can be influenced by flow – often, higher flows will create conditions that no longer obstruct fish migration. Natural physical barriers, such as waterfalls and boulder clusters, can change shape and, hence, the degree of obstruction, over time, as geomorphic processes, including erosion and sediment transport, alter the configuration of the stream channel.

The barriers which determine the upstream distribution of anadromous salmonids in Battle Creek include a waterfall located at river mile 13.48 on the North Fork of Battle Creek and a series of boulder-clusters at river mile 18.85 on the South Fork near Panther Creek.

Redding Area Geologic Map; Koll Buer, CDWR, Red Bluff, California, pers. comm.). The geology and hydrology of the rivers draining Mt Shasta have similar hydrologic features including high baseflow and large cold springs. However, as stated above, anadromous fish access to the rivers draining Mt. Shasta are now blocked to by Shasta Dam.

During the dry season, the valley reach of Battle Creek is not significantly diverted which allows a complete year-round connection to the Sacramento River for migratory fish. There are two agricultural diversions and diversions for Coleman National Fish Hatchery (CNFH) in the valley reach. During the wet-season, the valley reach of the stream has a natural unimpaired streamflow pattern which accommodates the migratory fish that move at that time of the year, including spring-run chinook, winter-run chinook, and steelhead.

Above the valley reach, the stream has been extensively developed to produce hydroelectric power using a continuous series of small “run of the river” diversions (Figure 3). There are eight small diversion dams that divert a portion of the runoff from the two forks of the creek into canals leading to PG&E’s hydroelectric power plants that release the water back to the creek. In addition, a number of tributaries to the forks of Battle Creek have very small diversions diverting additional runoff into the canals leading to power plants operated by PG&E and others. Two minor reservoirs, Macumber and North Battle Creek Reservoirs, are located on North Fork Battle Creek and store a total of 1,500 acre feet of water. These reservoirs have little effect on seasonal changes in streamflows.

Figure 3. Schematic of water conveyance systems in Battle Creek including selected portions of the Battle Creek Hydroelectric Project and Coleman National Fish Hatchery.
(Note: This schematic is not to scale).

Anadromous Fish Populations

Importance of Battle Creek

The anadromous fish that inhabit Battle Creek include chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), and Pacific lamprey (*Lampetra tridentatus*). There are four distinct races, or runs, of chinook salmon that occur in the upper Sacramento River--more runs than any other river system--and historically all four runs, including winter-run, spring-run, fall-run, and late-fall-run, occurred in Battle Creek (Yoshiyama et al. 1996). At present, two of the four runs, including winter-run and spring-run, are at remnant status. Other species of salmon occasionally stray into Battle Creek. During a ten-year period (1949 to 1959), 45 individual salmon from salmon species including pink, chum, sockeye and coho salmon, were recovered with chinook salmon at the CNFH (Hallock and Fry 1967).

The unique variability of chinook salmon life histories is due to a variety of factors including their remarkable adaptability, the diverse habitats that were historically available in the Sacramento River basin such as spring-fed streams that remain cool all summer, and the moderate climate of California allowing ice-free stream conditions (Vogel and Marine 1991; CDFG 1993c; Healy 1993). A number of genetic differences, such as run-timing, have been discovered in chinook salmon (NMFS 1997a; CDFG 1998b) and it is expected that ongoing research will continue to discover more unique genetic differences.

Sacramento River chinook salmon runs are designated by the seasons during which adults enter San Francisco Bay to begin their upstream spawning migrations. While the fall-run and late-fall-run both spawn shortly after arriving on the spawning grounds, the spring-run and winter-run are especially adapted to stay in the vicinity of the spawning area for several months before they spawn. This ability to migrate upstream in the spring and winter months, long before their spawning time, allows these special runs to access the mountain reaches of the stream that are colder and out of reach of the other runs that migrate in fall when water is low. The placement of dams in the Sacramento River system has blocked many of the historic spawning areas in the mountains (CDFG 1993c).

Battle Creek has been regarded as an uniquely important salmon-producing watershed because of the large numbers of chinook salmon that used to be produced there and because of the diversity of the four races of chinook that inhabit Battle Creek. Early fisheries investigators claimed that Battle Creek was the most important salmon-producing tributary to the Sacramento River when its ecosystem had its original form and function (Rutter 1904; CDFG 1993c). Others have noted the uniqueness of having four phenotypically and genetically distinct races of chinook salmon within the watershed (Yoshiyama et al. 1996; NMFS 1997a; CDFG 1998b), something that occurs nowhere else with the exception of populations in the Sacramento River artificially confined downstream of Shasta Dam.

At present, the only other population of winter-run chinook outside of Battle Creek occurs in the Sacramento River downstream of Shasta Dam. The majority of this population spawns in the reach between Keswick Dam and Cottonwood Creek where high water temperatures are predicted to periodically threaten these fish. USBR's (1991; their Table VI-6)

2020-level modeling results predicted that mean monthly summer/fall water temperatures will exceed 62°F from 4 to 9 years out of 100. During these years, there would be “no expected reproductive success” of the winter-run chinook. Similarly, mean monthly summer/fall water temperatures were predicted to be stressful (i.e. exceed 60°F with 50 percent egg mortality at 12 days) from 9 to 21 years out of 100 (Table VI-5b in USBR 1991). Climatic processes which drive water temperature in the Sacramento River are serially correlated, meaning that warm years generally follow warm years while cold years generally follow cold years. In other words, it is likely that lethal or stressful conditions will occur in consecutive years. In the event that water temperatures were lethal in 3 or 4 consecutive years, during, say, a drought, the Sacramento River population of winter-run chinook would likely be extirpated. Therefore, restoration of the Battle Creek population of winter-run, residing in habitat less likely to be impacted by the same conditions as the Sacramento River, is extremely important to guard against catastrophic loss of the whole winter-run species.

Battle Creek is still recognized as the watershed with the best potential for restoring salmon and steelhead. CDFG (1993c) suggested that restoration of Battle Creek would provide a unique opportunity to restore a drought-resistant population of winter-run chinook salmon as a safe-guard against possible extinction of the primary population of this race located in the upper Sacramento River. CDFG (1996c) regarded Battle Creek as one of four upper Sacramento River tributaries that offer the best opportunities for restoration of native and wild steelhead populations. Furthermore, the location and excellent water quality and quantity in Battle Creek fostered recognition that Battle Creek was the best site for location of a hatchery intended to mitigate for the negative impacts of Shasta Dam (Hedgpeth 1944). Finally, of several Sacramento River tributaries reviewed in its restoration plan, USFRHAC (1989) singled out Battle Creek as a key watershed for restoration, and the only such watershed impacted by hydroelectric development.

Fish Species Life History

Steelhead inhabit the Battle Creek watershed throughout the year at various life stages. The typical spawning period for steelhead populations in the upper Sacramento River, including, presumably, the Battle Creek population, begins in December and lasts through April (Table 2; Schafer 1980; CDFG 1990). Steelhead eggs hatch by late-May and the juveniles likely spend a year or more in Battle Creek before migrating to the Pacific Ocean. CDFG (1990) and Hallock et al. (1961) provide many more details about the life history and habitat requirements of steelhead.

The presence of four races of chinook in Battle Creek entails a more complicated description of species life history as each of the freshwater life stages may be found in appropriate sections of Battle Creek each month of the year (Table 2). Table 2 illustrates the general timing of each run of Sacramento River chinook above Red Bluff Diversion Dam and their respective life stages. The actual timing of each life stage varies during the year and among years, primarily as a function of weather, streamflow, and water temperature (Vogel and Marine 1991). Life history patterns of wild chinook have not been well documented within Battle Creek, with the exception of limited work in the early 1900s (Rutter 1902, 1903), primarily because of the low population sizes that have inhabited this stream system above CNFH during most of the 20th century. Precise genetic characterization of each race of Sacramento River chinook is problematic due to the

incomplete understanding of salmon genetics at this time and to suspected genetic hybridization between spring and fall-run chinook (CDFG 1993c, CDFG 1998b). For example, in the Feather River, where there is hatchery propagation of both fall-run and spring-run chinook, the operations caused hybridization (CDFG 1998); however, there are no current spring-run propagation programs on Battle Creek² or the upper Sacramento River. Conversely, it is possible that late-arriving spring-run that over-summer in the Sacramento River could be inadvertently spawned with fall-run chinook at CNFH. Most distinctions between the four races of chinook salmon have been based on phenotypic traits (spawning time, run-timing, and appearance) rather than genetic differences (J. Smith, USFWS, Red Bluff, California, pers. comm.; CDFG 1996d). However, new analysis techniques are proving reliable for the identification of winter-run (CDFG 1998c). A complete discussion of life history stages of the four races of chinook is beyond the scope of this document. However, the following list of documents are available to provide much more detail: Hallock (1971); Schafter (1980); CDFG (1990, 1993c, 1996d); Vogel and Marine (1991); USBR (1991, 1998a); Healey (1993); Spence et al. (1996); USFWS (1997c, 1997b, 1998a); Bartholow et al. (unpubl.).

Adult hatchery-origin winter-run enter the Battle Creek watershed between January and July, with the peak of the migration occurring at the CNFH barrier dam in late-April (Table 2; USFWS 1996a). The peak of the winter-run chinook spawning period is mid-June as erratic winter flows stabilize and subsequent offspring can take advantage of the cooling effects of headwater springs. Most juvenile winter-run chinook leave the Sacramento River watershed by mid-March of the following year (USFWS 1993).

Naturally-spawning spring-run chinook enter the watershed as adults from mid-March to mid-October, though no specific peak has been observed in the run at the CNFH barrier dam (Table 2; USFWS 1996a). In general, adult spring-run chinook inhabit cool pools until they spawn from late-August to mid-October (CDFG 1996d, 1998b). Emigration of juvenile spring-run is highly variable with observations ranging between spring outmigration of juveniles and fall outmigration of either yearlings or fingerlings (CDFG 1998b). Adult fall-run chinook of both hatchery and naturally-spawned origin migrate into the Battle Creek watershed from July through December with a peak in migration usually occurring at the CNFH barrier dam during October (Table 2; T. Parker, USFWS, Red Bluff, California, pers. comm.). The peak of natural spawning is early-November (CDFG 1996d) and most of the subsequent offspring leave Battle Creek by the end of June of the following year (CDFG 1990; Vogel and Marine 1991).

Naturally spawning late-fall-run chinook enter Battle Creek as adults from mid-October to mid-April and spawn from January through April with a peak in February (Table 2). The offspring of these fish leave the watershed by mid-December (CDFG 1990; Vogel and Marine 1991).

² The Battle Creek Hatchery and the Coleman Hatchery collected spring-run salmon for propagation from 1942 to 1946. However, these efforts were largely unsuccessful and were discontinued (USFWS 1993; Yoshiyama et al. 1996, Black 1997).

Table 2. Seasonal occurrence of selected life stages of anadromous salmonids in the Upper Sacramento River, California, based on Schafter (1980) and Vogel and Marine (1991).

Life Stage	Species	Month											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Adult Migration	Winter Chinook				X								
	Spring Chinook					X							
	Fall Chinook										X		
	Late-Fall Chinook	X											
	Steelhead												
Spawning	Winter Chinook						X						
	Spring Chinook									X			
	Fall Chinook											X	
	Late-Fall Chinook		X										
	Steelhead												
Juvenile Residence	Winter Chinook												
	Spring Chinook												
	Fall Chinook												
	Late-Fall Chinook												
	Steelhead												

X = Denotes approximate peak of life stage if a significant peak occurs.

Current Anadromous Fish Population Status

Of the four races of chinook salmon which inhabit Battle Creek, only the winter-run chinook is listed as an endangered species under both the federal Endangered Species Act (ESA; NOAA 1994) and the California Endangered Species Act (CESA). The spring-run chinook salmon is a federally-proposed endangered species (NOAA 1998) and a State-listed threatened species (CDFG 1998c). The steelhead is a federally-listed threatened species and a State species of concern. Fall and late-fall chinook salmon are currently proposed as threatened under the ESA.

Winter-Run Chinook Salmon

Winter-run chinook spawn during California's dry season obligating them to streams and rivers having stable summer streamflow largely derived from cool, constant-temperature springs (USFWS 1963). This type of habitat currently occurs in the foothill reaches of Battle Creek as small refugia but was formerly more abundant and well-connected prior to the extensive network of diversions constructed on the creek and its tributaries to produce hydroelectric power. In recognition of the unique environmental conditions in Battle Creek, it was proposed in 1962 that the natural streamflows of the creek be restored to meet the requirements of winter-run and spring-run chinook (USBSFW 1962).

Battle Creek historically supported winter-run chinook but no reliable records exist that document the size of the populations. Systematic counts were not made during the high-flow winter months when adult winter-run migrate upstream. The occurrence of successfully reproducing winter-run in Battle Creek was first documented beginning in 1898 and again in 1900 when the U.S. Fish Commission collected salmon fry in specially designed nets (Rutter 1902, 1903). Small, newly emerged salmon fry were captured in Battle Creek in September and early-October (Rutter 1902, 1903) of a size that could only have been winter-run (USFWS 1992). The origin of these fry was restricted to Battle Creek because of the place and time of capture. The fry could not have been prodigy of Sacramento River spawning populations due to lethal water temperatures, over 70°F, in the river prior to construction of Shasta Dam (USFWS 1949). The nearest river reach with non-lethal water temperatures was the McCloud River located over 50 river miles from where the newly emerged fry were trapped (USFWS 1940). In addition, the recorded trappings occurred during dry months of below-normal water years (CDPW 1923). Finally, fry as small as the ones captured in Battle Creek would have been unlikely, due to their size, to migrate the 50 miles from the McCloud River and up Battle Creek to the trap site, even if water conditions in the Sacramento River were not lethal.

During the late-1940s and early-1950s, a spawning run of adult winter-run chinook was encountered on Battle Creek when CNFH began late-fall-run egg-taking operations (USFWS 1987a). In the spring of 1958, 309 winter-run were trapped in Battle Creek at the CNFH (USFWS 1963). In 1955, 1958, and 1959 CNFH made failed attempts to artificially propagate winter-run collected from both Battle Creek and Keswick Dam (USFWS 1982a). In the 1950s to the early-1960s, CDFG reported the existence of a

significant winter-run population in Battle Creek during a statewide inventory of salmon and steelhead resources (CDFG 1965a). There was no reliable estimate of the abundance of the population in the stream system available at this time other than the observations in lower Battle Creek associated with CNFH operations.

Eighteen dead and spawned-out winter-run chinook and six live spawners were observed during surveys of the lowermost reach of South Fork Battle Creek (Coleman Reach)³ from June 8 to July 9 of 1965 (CDFG 1966). The natal stream for these salmon may have been North Fork Battle Creek instead of the South Fork. Water in the Coleman Reach at this time was dominated by North Fork water resulting from a major trans-basin power diversion of North Fork water into the South Fork. Furthermore, the South Fork site where the spawning occurred was likely not the natal stream for these fish because water temperatures were lethal to developing embryos during all years while water temperatures in the spring-fed reaches of the North Fork were cooler.

During the last two years (1997-98), the USFWS has generated partial estimates for salmon using a trap at the terminus of the ladder at the CNFH barrier dam during the winter-run and spring-run chinook migration period. These partial estimates indicate Battle Creek has a run of hatchery-origin winter-run chinook from past artificial propagation efforts at CNFH (USFWS 1995b, 1996a) and a remnant population of wild winter-run, as indicated by the catch of several non-hatchery-origin winter-run in 1998 (USFWS 1998b). Also in 1998, approximately 100 hatchery-origin winter-run chinook entered the Battle Creek watershed upstream of the CNFH barrier dam (USFWS report to the BCWG, July 7, 1998).

Spring-Run Chinook Salmon

A small spring-run chinook population ascends the North and South forks of Battle Creek to spawn (USFWS 1987a). Early estimates of abundance (1940-50) are based upon redd surveys and carcass counts, while latter estimates (1990s) are based upon more systematic counts during the spring months when most adult spring-run are expected to migrate up Battle Creek (Figure 4). However, early studies by the USFWS (1957) stated that it was probable that some spring-run chinook remain in the cool waters of the large pools in the Sacramento River during summer before ascending Battle Creek just ahead of the fall-run.

Surveys conducted by the USFWS (1940) in the late-1930s and early-1940s reported a small spring-run and a larger fall-run. At the start of Coleman Hatchery operations, a failed spring-run propagation effort collected 227; 1,181; 468; and 2,450; spring-run from Battle Creek in the years from 1943 to 1946, respectively, indicating that a large population was present in the creek (USFWS 1949). Successful reproduction of spring-run chinook was apparent from fyke net sampling in Battle Creek, upstream of the

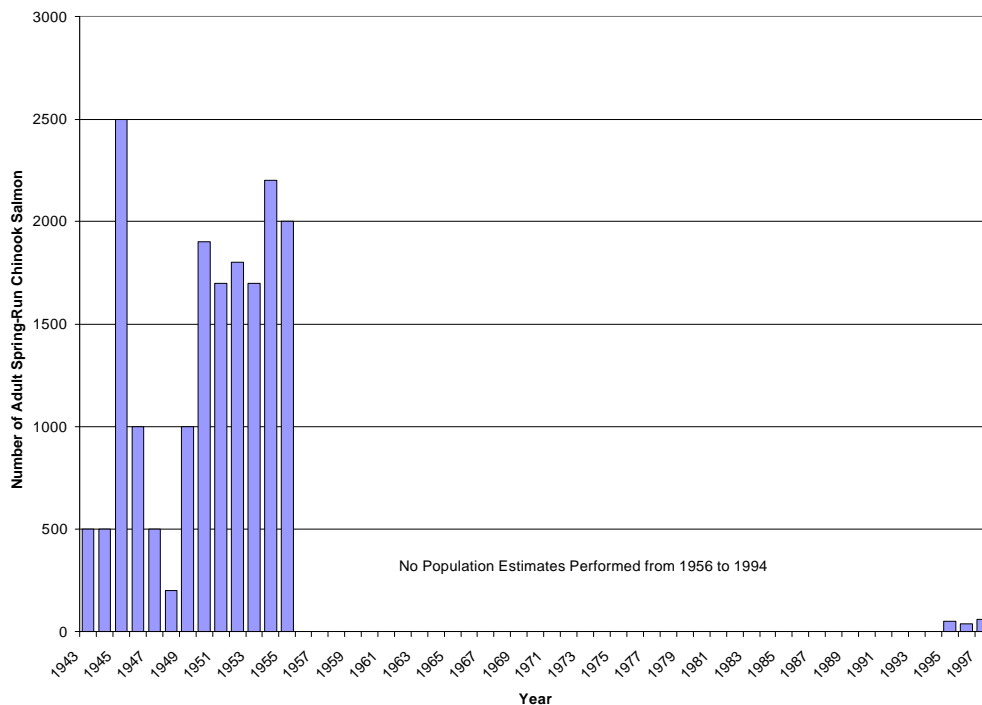
³ Proper names of stream reaches in this document follow the convention of naming stream reaches by the dam or feature at the upstream end of the reach. For example, the "Coleman Reach" refers to the stream reach downstream of Coleman Dam (Figure 3).

Coleman Hatchery, during 1949 to 1953. Only spring-run chinook were permitted to migrate upstream of the Coleman Hatchery rack during this period (USFWS 1958). From 1,700 to 2,200 adult spring-run spawned in Battle Creek during the period from 1952 to 1956 (CDFG 1961).

During stream surveys in the early-1960s, it was reported that some spring-run hold in the pools of Battle Creek near the mouth of Baldwin Creek, in North Fork Battle Creek below Eagle Canyon Dam (CDFG 1966), and in South Fork Battle Creek above Panther Creek (Tehama County 1983). During June 1970, the fish ladder at Eagle Canyon Dam was inspected by CDFG Screen Shop personnel and found to be partially damaged and impairing passage⁴. There were an estimated 40 to 50 spring-run chinook in the immediate vicinity of the dam (CDFG 1970a; Phil Warner, CDFG, pers. comm.).

From 1995 to 1998, the USFWS has generated partial estimates for spring-run using ladder counts at the CNFH barrier dam. These partial estimates indicate that Battle Creek presently has a run of 50 to 100 spring-run (CDFG 1996e, 1997a; USFWS 1996a, 1997a).

Figure 4. Numbers of adult spring-run chinook salmon in Battle Creek, California.



⁴ This ladder and others on Battle Creek were subsequently repaired and modified by PG&E in consultation with CDFG to improve fish passage and reduce maintenance requirements.

Fall-Run Chinook Salmon

Fall-run chinook salmon comprise the largest population of chinook salmon in Battle Creek. During the last three years, an average of 225,049 adult fall-run produced in Battle Creek have returned to the watershed or have been captured in ocean fisheries (Table 3; CAMP 1998). An estimated 90 percent of this total were produced at CNFH (CAMP 1998). On average, 138,987 of these fish were captured in ocean fisheries, 32,842 fish were collected by the CNFH and 53,221 fish spawned and/or died in Battle Creek outside of CNFH (Table 3; CAMP 1998).

Access by fall-run chinook salmon to the Battle Creek watershed upstream of CNFH has historically been restricted by operation of the CNFH barrier dam to collect broodstock. However, during the period from 1985 to 1989, fall-run were intentionally allowed passage over the barrier dam but were confined downstream of Wildcat and Coleman dams in 1986 to 1989. These fish were in the Wildcat, Coleman, and Inskip reaches, in numbers decreasing with distance upstream, during an aerial survey of Battle Creek in 1986 (Dave Hoopaugh, retired CDFG, pers. comm.).

Access by fall-run chinook salmon to the Battle Creek watershed upstream of CNFH has historically been restricted by operation of the CNFH barrier dam to collect broodstock. However, during the period from 1985 to 1989, fall-run were intentionally allowed passage over the barrier dam. During an aerial survey in 1985, fall-run chinook were observed in the Wildcat, Coleman, and Inskip reaches, in numbers decreasing with distance upstream (Dave Hoopaugh, retired CDFG, pers. comm.). From 1986 to 1989, fall-run were intentionally confined downstream of Wildcat and Coleman dams by the closure of fish ladders at these dams.

Table 3. Numbers of fall-run and late-fall-run chinook salmon in Battle Creek in 1995, 1996 and 1997 (CAMP 1998).

<u>Fall-Run Chinook Salmon</u>				
Fall-Run Chinook	Total Carcass Count	Hatchery Component	Ocean Harvest	Total Production
1995	56,515	26,677	200,009	283,201
1996	52,404	21,178	84,934	158,516
1997	50,743	50,670	132,017	233,430
Average	53,221	32,842	138,987	225,049

<u>Late-Fall-Run Chinook Salmon</u>				
Late-Fall-Run Chinook	Total Carcass Count	Hatchery Component	Ocean Harvest	Total Production
1995	NA	1,337	3,214	4,551
1996	NA	4,578	5,284	9,862
1997	NA	3,069	3,995	7,064
Average	NA	2,995	4,164	7,159

Late-Fall-Run Chinook Salmon

Late-fall-run chinook salmon comprise the second largest population of chinook salmon in Battle Creek. During the last three years, an average of 7,159 adult late-fall-run produced in Battle Creek have returned to the watershed or have been captured in ocean fisheries (Table 3; CAMP 1998). On average, 4,164 of these fish were captured in ocean fisheries, 2,995 fish were collected by the CNFH and an unspecified amount spawned and/or died in Battle Creek outside of CNFH (Table 3; CAMP 1998).

Steelhead

Steelhead spawn in practically every tributary of the upper Sacramento River, and appear to do so in numbers proportionate to a given tributary's runoff. That is, large streams such as Mill, Deer, and Battle creeks have the largest runs (Hallock et al. 1961, 1989). Actual numbers of naturally spawning steelhead in these streams are generally unknown. However, an average of 1160 steelhead per year migrated into Mill Creek during a 10 year period from 1954 to 1963 (CDFG n.d.).

From 1967 to 1991, estimated numbers of naturally spawning steelhead passing Red Bluff Diversion Dam ranged from a high of 19,615 in 1968 to a low of 470 in 1989. (Table 4; CDFG 1994c). Based on data from 1967 to 1974, 28 percent of the adult steelhead migrating past Red Bluff Diversion Dam spawned in the upper reaches of the Sacramento River tributaries including Battle, Cottonwood, and Cow Creeks, 28 percent spawned at the CNFH, and the remaining 46 percent were caught by sport anglers; very few steelhead spawn in the mainstem Sacramento River (USFWS 1984).

Beginning in 1953, naturally-spawning steelhead from Battle Creek were used by CNFH to develop a program of stocking hatchery-reared steelhead in the upper Sacramento River to supplement natural spawning runs for sport fishing uses (Hallock et al. 1961; CDFG 1994a). Yearling steelhead releases from CNFH ranged from 166,000 in the 1950s to 1.5 million annually beginning in the 1960s. In the 1990s, it was estimated that 70 to 90 percent of the steelhead passing Red Bluff Diversion Dam originated from CNFH (Frank Fisher, CDFG Inland Fisheries Division, Red Bluff, pers. comm. as cited in USFWS 1993). The effect of this level of hatchery production on naturally-produced steelhead has not been evaluated in the upper Sacramento River (Hallock 1989), R

Table 4. Estimated number of natural spawning steelhead passing Red Bluff Diversion Dam and steelhead returning to CNFH from 1967 to 1991 (CDFG 1994c).

Year	Natural Spawning Steelhead passing Red Bluff Diversion Dam		Year	Natural Spawning Steelhead passing Red Bluff Diversion Dam	
	Steelhead Returning to CNFH	Steelhead Returning to CNFH		Steelhead Returning to CNFH	Steelhead Returning to CNFH
1967	15,312	1,532	1981	3,363	1,118
1968	19,615	3,229	1982	2,757	1,275
1969	15,222	4,939	1983	3,486	938
1970	13,240	4,046	1984	2,036	529
1971	11,887	3,742	1985	4,489	2,084
1972	6,041	1,486	1986	3,769	2,299
1973	8,921	2,645	1987	2,963	1,176
1974	7,150	1,834	1988	1,872	915
1975	5,579	1,099	1989	470	492
1976	8,902	2,162	1990	2,272	1,319
1977	6,099	2,069	1991	991	991
1978	2,527	697			
1979	3,499	865	Average (1967 to 1991)	6,574	1,910
1980	11,887	4,264			

living in freshwater pools for at least five years as larvae, lamprey undergo a transformation to a toothed adult stage at which time they migrate downstream to the ocean and become parasitic on other fish (Hart 1988). Little is known about the distribution of lamprey within Battle Creek. Their presence in the Coleman Reach was noted in 1989 but data were insufficient to generate indices of abundance (TRPA 1998e). Nothing is known about historical trends in lamprey populations within Battle Creek.

Resident Fish Populations

At least 12 species of fish reside in Battle Creek in addition to the anadromous fish detailed in the previous section (Coots and Healey 1966; CDFG 1978, 1987; TRPA 1998e). These fish either spend the duration of their lives within Battle Creek or move from Battle Creek into tributaries or the Sacramento River. Of the 12 “resident” fish, eight are native to the Sacramento Basin including: rainbow trout (*Oncorhynchus mykiss*), pike minnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), California roach (*Hesperoleucus symmetricus*), riffle sculpin (*Cottus gulosus*), speckled dace (*Rhinichthys osculus*), hardhead (*Mylopharodon conocephalus*), three-spine stickleback (*Gasterosteus aculeatus*) and tule perch (*Hysterocarpus traski*). Four other species that have been observed within Battle Creek, including brown trout (*Salmo trutta*), smallmouth bass (*Micropterus dolomieu*), green sunfish (*Lepomis cyanellus*) and golden

shiner (*Notemigonus crysoleucas*), are species that were not historically present within the Sacramento Basin.

The general distribution of resident fish within Battle Creek conforms to patterns of distribution typical of Central Valley fish assemblages (Moyle and Cech 1988). For example, rainbow and brown trout have been documented in both forks of Battle Creek upstream of the barriers which stops anadromous fish migration (CDFG 1968; Tehama County 1983) and both species have been stocked in these reaches upstream of anadromous fish habitat since at least 1940 (CDFG fish stocking records for Battle Creek). The native riffle sculpin and speckled dace also inhabit the upper portion of the Battle Creek watershed (Susan Chapelle, Forest Fisheries Biologist, Lassen National Forest, Susanville, California, pers. comm.). Brook trout (*Salvelinus fontinalis*) were also stocked in the upper South Fork but these stockings did not create viable populations (Tehama County 1983). Populations of other fish species introduced to the non-anadromous portion of the Battle Creek watershed, including pike minnow, California roach and golden shiner, have also been established within Macumber and North Battle Creek Reservoirs on the North Fork (CDFG 1978).

Rainbow trout, brown trout, and riffle sculpin were the only fish species found within the uppermost reaches of both forks of Battle Creek in a 1989 study of fish distribution within the portions of the watershed accessible to anadromous fish (Table 5). However, this study did not distinguish between steelhead and rainbow trout (two different forms of the same species), and so it is not clear how many rainbow trout observed by TRPA (1998e) were resident and how many were anadromous.

As predicted by Moyle and Cech (1988), lower elevation reaches of Battle Creek contained chinook salmon, pike minnow, Sacramento sucker, California roach, riffle sculpin, speckled dace, tule perch, and the non-native smallmouth bass in 1989 (TRPA 1998e). Hardhead and three-spine stickleback are routinely observed by USFWS personnel in the CNFH trap and abatement pond. These lower elevation species were confined to reaches downstream from Inskip and Eagle Canyon⁵ dams, in an area where rainbow trout densities were substantially lower than in the upstream reaches (Table 5).

Details of the life history of the resident fish species inhabiting Battle Creek can be found in Moyle (1976a). Although relatively little attention has been given to fish species resident to Battle Creek, with the possible exception of the prized game fish, rainbow and brown trout, it is likely that resident fish species have suffered as the result of disrupted ecosystem processes within Battle Creek (Bay Institute 1998) including reductions of instream flow (USBR 1998a), changes in gravel transport, changes in temperature regimes, entrainment of fish and macroinvertebrate prey items into the hydroelectric canal system, introduced species (Moyle 1976b), and disruptions to fish passage caused by dams.

⁵ At the time of the TRPA (1998e) field investigations in 1989, fish ladders at Wildcat and Coleman dams were closed at the request of resources agencies and prevented chinook salmon from migrating to reaches higher in the watershed.

Selected Stream-Dependent Plants and Animals

Hundreds, if not thousands, of vertebrate, invertebrate, and plant species depend on the stream systems of the Central Valley (Erman 1996; Bay Institute 1998), including Battle Creek. Many of these species are known to be sensitive to changes in flow, water quality, water temperature, and sediment transport and deposition (Erman 1996). This Restoration Plan will highlight just a few examples of the vertebrates, invertebrates, and plants expected to benefit from the restoration of Battle Creek.

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is currently listed as a threatened species under the ESA, and as an endangered species under the CESA, as a result of a severely declining populations primarily affected by human disturbance and the loss of habitat (CDFG 1997c; USBR 1998a). About 45 percent of all eagle nests occurring in California are found within Shasta County – two of these are located within approximately ten air miles of the foothills reaches of the North and South forks of Battle Creek (USFWS 1986a; USBR 1998a).

Bald eagles are predatory birds that rely mostly on fish and, therefore, require large bodies of water or free flowing streams with abundant fish and adjacent snags or perches for hunting (Evans 1992; CDFG 1997c). Bald eagles can be so dependent on their salmon prey that some eagle populations have been shown to be serially correlated with changes in salmon abundance (USBR 1998a). Therefore, restoration of fish populations within Battle Creek are likely to assist the recovery of bald eagles (USBR 1998a). For example, in the nearby montane riparian habitat on the Pit River, bald eagle populations increased in response to dramatic increases in fish populations resulting from increased river flows (Hunt 1987; USFWS 1997h).

Valley Elderberry Longhorn Beetle

The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) was classified as a federally-listed threatened insect species in 1980. This beetle requires Valley elderberry bushes (*Sambucus melanocarpa*) for larval and adult life cycles. Valley elderberry bushes are present in the riparian area within the Battle Creek watershed. Restored stream flows in Battle Creek would increase the health of the riparian vegetation along the stream, especially in the South Fork where significant side channels and stream-side terraces exist (USBR 1998a). Therefore, populations of the valley elderberry longhorn beetle could increase if the abundance of valley elderberry bushes increases in response to increased instream flow.

Table 5. Estimated density of fish (fish/mile) weighted by the amount of habitat sampled in reaches of the Battle Creek watershed in the summer 1989. Data were taken from a draft study of fish distribution within Battle Creek (TRPA 1998e). This study only examined reaches downstream of impassable barriers to anadromous salmonid migration.

Reach	Fish Density (fish/mile)										
	Chinook Salmon ⁶	Steelhead / Rainbow Trout ⁷	Sacrament o Sucker	California Roach	Pike Minnow	Larval Roach/ Pike Minnow ⁸	Speckled Dace	Riffle Sculpin	Tule Perch	Brown Trout	Smallmouth Bass
Keswick	0	4,938	0	0	0	0	0	85	0	300	0
North Battle Creek Feeder	0	7,011	0	0	0	0	0	0	0	360	0
Eagle C. and Wildcat	18	1,276	4,499	15,279	978	7,663	12	125	880	0	0
South	0	6,279	0	0	0	0	0	0	0	0	0
Inskip	0	74	1,864	6,290	1,897	11,732	0	43	0	0	0
Coleman	12	55	621	376	932	7,204	396	3	290	0	0
Mainstem	0	45	190	152	650	410	10	38	0	0	905

Lamprey of unknown species were observed in the Coleman Reach but no estimates of abundance could be derived for this fish.

⁶ At the time of the TRPA (1998e) study, fish ladders at Wildcat and Coleman dams were closed and prevented chinook salmon from migrating to reaches higher in the watershed.

⁷ No distinction was made between steelhead and rainbow trout in TRPA (1998e).

⁸ No distinction was made between larval California roach and larval pike minnow in TRPA (1998e).

History of Battle Creek Watershed

The Battle Creek watershed is located in what was the homeland of the Yana people at the time the first Europeans arrived in the region (CDWR 1997). The Yana inhabited the upper Sacramento River valley and foothills east of the river. The political and settlement organization of the Yana was based on a system of triblets consisting of a major village, where the principal chief resided and an assembly house was located, and several other affiliated villages. The Yana maintained a close relationship to floral and faunal resources in their territory which ranged from 300 to 10,000 feet in elevation along the western slope of Mt. Lassen. Acorns, roots, tubers, and bulbs as well as deer, quail and small mammals provided the main staple foods for the Yana. Fishing was an important secondary food source. Salmon were taken with spears and harpoons while trout and suckers were captured with bone gorges, seines, traps, and plant poisons.

The first contact between the Yana and Europeans probably occurred as a result of the Arguello exploratory expedition of 1821 (CDWR 1997). Subsequent contacts with Europeans would have been with trappers from the Hudson's Bay Company. Several land grants were made to individuals in the upper Sacramento Valley and foothills in 1844. By 1848, the California-Oregon trail and the Lassen trail passed through Yana territory. The use of the foothills for grazing and hunting by American settlers increased hostilities and ultimately led to massacres of the native population. From 1880 to 1900 the Yana population was reduced from 1,900 to about 100 people (Johnson 1978).

Hydroelectric Development

By the beginning of the 20th century, urban growth and industrial development strained the area's fuel resources. Massive amounts of timber were consumed to fire the boilers of steam-powered mining machinery and to operate smelters. The pressure placed on the local wood fuel supply to support the urban growth and mining was probably the primary incentive to develop hydroelectric power in Shasta and Tehama counties (Reynolds and Scott n.d.). The Battle Creek Hydroelectric Project was a principal result of that effort (CDM 1947).

Hydroelectric development began on Battle Creek with the construction of Volta Powerhouse by Keswick Electric Power Company in 1901 (USRFRHAC 1989). This was followed by South and Inskip powerhouses in 1910 and Coleman Powerhouse in 1911. This system of powerhouses was acquired by PG&E in 1919. The project initially was licensed by the Federal Power Commission in 1932 and was relicensed in 1976 for a period of 50 years. Volta II Powerhouse was constructed in 1980.

As it exists today, PG&E's Battle Creek Hydroelectric Project (FERC No. 1121) consists of: five powerhouses (Volta, Volta II, South, Inskip, and Coleman), two small storage reservoirs (North Battle Creek and Macumber), three forebays (Grace, Nora, and Coleman), five diversions on North Fork Battle Creek (Al Smith, Keswick, North Battle Creek Feeder, Eagle Canyon, and Wildcat), three diversions on South Fork Battle Creek

(South, Inskip, and Coleman), numerous tributary and spring diversions, and a network of some 20 canals, ditches, flumes and pipelines. Please refer to the schematic illustrating selected portions of this complex water conveyance system (Figure 3).

Several other hydroelectric projects exist within Battle Creek outside of the reaches inhabited by anadromous salmonids and, therefore, have little or no effect on anadromous salmonids. These include FERC# 3948 and FERC# 8357, on Bailey Creek; FERC# 5697 and FERC# 4714 on Digger Creek; and FERC# 8476 and FERC# 8550 on Millseat Creek. In addition, the Lassen Lodge Project on South Fork Battle Creek (FERC# 11157-001) is currently under consideration by FERC but has not been constructed. It would be a 7,000 KW facility above the PG&E project and could affect anadromous salmonids if a barrier at the Panther Creek grade is naturally or artificially modified, or when anadromous fish pass this barrier during high flows. There is also concern over whether or not the Lassen Lodge Project would have flow continuance mechanisms in place to prevent short-term dewatering during powerhouse shut-downs.

Fisheries Management

Hatchery Operations

Coleman National Fish Hatchery

Initially, fisheries management efforts in Battle Creek were primarily related to the restoration and enhancement of salmon populations in the upper Sacramento River basin as a whole. In 1895, a fish hatchery was erected at the mouth of Battle Creek (SBFC 1896) to keep up “the supply of salmon in the Sacramento River ..[where] there are now no natural spawning beds in the Sacramento basin that amount to anything ... with the exception of the streams where hatcheries are located” and “natural spawning beds ... between Redding and Tehama” (SBFC 1896). This hatchery was believed to have done little to restore fish populations to Battle Creek (USBSFW 1962).

During construction of Shasta Dam, which was initiated in 1942, fisheries management in Battle Creek was intensified to mitigate for the effects on salmon populations caused by this construction (Needham et al. 1940, 1943). A resultant program, commonly referred to as the “Shasta Salmon Salvage Plan,” led to the construction of the original Coleman Hatchery. This facility was replaced in 1946 with the CNFH and is currently operated by the USFWS (USBSFW 1962).

In addition to facilities at the original Battle Creek site, CNFH also operates a fish trap at the base of Keswick Dam (USFWS 1949; USBR 1985). Keswick trap has been authorized and operated for collection of anadromous fish broodstock for Coleman Hatchery for 50 years. During that period the amount and species of broodstock has varied (USFWS 1982a). Because it is an essential element of CNFH, the trap is being modernized and upgraded (USBR 1985).

Since the 1940s, CNFH has produced or handled a wide assortment of fish species including fall-, late-fall- winter-, and spring-run chinook salmon, steelhead, rainbow trout, coho salmon, kokanee salmon, and warm water fishes (Black 1997), though it currently produces only fall- and late-fall-run chinook salmon and steelhead (USFWS 1996c). In 1998, the production of winter-run chinook salmon was moved from CNFH to the new Livingston Stone Hatchery at the base of Shasta Dam on the Sacramento River. Though the numbers of fish spawned, reared, and released from CNFH have varied over the years, in brood year 1997 CNFH released 1.15 million late-fall-run chinook salmon smolts, 550,000 steelhead yearlings, 21,000 winter-run chinook salmon smolts, 8 million fall-run chinook fry, and 12 million fall-run smolts (USFWS 1998d).

Other Hatcheries

Darrah Springs Hatchery is a State-run facility located at Darrah Spring on Baldwin Creek, a tributary to the mainstem Battle Creek. It is a key hatchery of the CDFG inland fisheries program and raises catchable trout for sport fisheries using a wide variety of strains including Eagle Lake rainbow trout, Pit River rainbow trout, and Mt. Shasta-strain rainbow trout.

Also located within the watershed are 12 private trout rearing facilities operated by Mt. Lassen Trout Farms, Inc. (MLTF). These facilities rear rainbow and brown trout for stocking in private ponds and lakes throughout California. They also produce rainbow trout eggs for shipment to out-of-state trout farmers (MLTF 1998). Though these facilities do not interact with fish populations in the anadromous habitat of Battle Creek, some facilities, such as MLTF's main broodstock facility, are closely proximate to hydroelectric power canals. Concern has been expressed regarding disease transmission between the hydroelectric power canals and these facilities (Phil Mackey, MLTF, presentation to Spring-Run Working Group, 1996). For example, infected juvenile salmon living in unscreened canals could serve as vectors for disease if borne by predators to hatchery facilities.

Fish Passage at Dams

Fish ladders are devices constructed to allow migrating fish passage over dams or barriers. Fish ladders can also be closed to intentionally limit the distribution of fish within a watershed or collect broodstock for hatchery operations. These devices have been installed at all PG&E-operated dams and at the CNFH barrier dam. Fish screens are used to prevent fish, especially those migrating downstream, from being entrained into water diversions. Fish screens have been installed at PG&E-operated water diversions but are no longer operational (CDWR 1998).

CNFH Barrier Dam

The abundance and distribution of salmon and steelhead populations in Battle Creek has been artificially managed by the operation of a large, permanent fish barrier dam

at CNFH since 1952 (CDFG 1951). Prior to that time, adult salmon were collected from Battle Creek at seasonally installed racks at the historic Battle Creek Hatchery (USFWS 1957). The existing permanent dam has a fish ladder that is closed to create a migration barrier during certain seasons of the year, except when high runoff events (exceeding 350 cfs) make the dam increasingly passable (USFWS 1995b). The mean monthly discharge of Battle Creek at CNFH during the December to March period ranges between 559 to 727 cfs (Figure 2) indicating that, on average, some passage is possible when the ladder is closed. The CNFH has always had a functioning fish passage facility that is left open for at least the period April through June, the principal migration period for spring-run.

Management of the CNFH barrier dam has been singled out as one of the factors controlling the abundance of salmon and steelhead in Battle Creek and an area of primary concern for the restoration of anadromous salmonids in the watershed (USFRHAC 1989; CDFG 1993c, 1996c; USFWS 1995a, 1997c; Bernard et al. 1996). Reasons for closing the barrier dam have included: collecting brood stock for the CNFH (USFWS 1998f); preventing fall-run and late-fall-run chinook salmon, that are highly infected with IHN virus, from transmitting disease to CNFH by entering areas of the watershed that serve as water sources for CNFH (USFWS 1990); temporally and spatially separating spring-run and fall-run fish to maintain/manipulate stock identity (USBR 1998a); preventing fish from reaching habitat degraded by lack of flow and large, unscreened diversions; preventing the swamping of habitat by huge numbers of hatchery reared fish; and monitoring fish movement into the Battle Creek watershed (USFWS 1996a). However, restoration actions recently undertaken in the watershed, and those proposed to take place in the near future, alleviate much of the former concern which prompted prolonged closures, suggesting that in the future, management of the CNFH barrier dam will accommodate the movement of wild salmon and steelhead so they can access the best stream reaches at the right times. For instance, the construction of ozone treatment facilities to disinfect water at CNFH alleviated disease concerns for the upstream passage of salmon (USFWS 1998f), and anticipated flow and habitat restoration actions, including screening diversions, will alleviate concerns for degraded quality and insufficient amount of habitat.

In light of USFWS and CDFG commitments to explore improvements to the CNFH barrier dam that complement or enhance restoration of natural spawners (USFWS 1998f; CDFG 1998f), the Battle Creek Working Group (BCWG) has convened a scientific panel to examine the merits and problems associated with closure of the barrier dam and will recommend management strategies for future operation of this facility. This panel's findings will be incorporated into future versions of this document.

Theoretical approaches to the trapping and handling of fish in hatchery programs developed in the Columbia River Basin may also apply to CNFH. In order to actually "restore" populations of anadromous salmonids with the use of hatcheries, the natural and wild stocks need to be fully separated. If not fully separated, the target populations may never be restored, they might be subject to the same catastrophic risks inherent in all hatcheries, or they may suffer from the same population declines and negative trends in survival commonly observed as hatcheries age (Bugert 1998). Criteria for effective

broodstock collection at the CNFH barrier dam should include: 1) an ability to collect only the targeted population for supplementation, 2) a capability to capture all age classes of the target population without injury or stress, 3) an equal collection efficiency during both the peak and nadir of the hydrograph, 4) an ability to sort hatchery and naturally produced salmonids, 5) unimpeded passage of non-targeted species and populations and, at times, most of those fish in the targeted population, 6) compatibility with State and federal rules governing dams. Finally, flexibility or contingency plans should be in place when hatchery tools (e.g. ozonation facilities or the barrier dam) do not perform as planned.

Fish Ladders Within the Battle Creek Hydroelectric Project

Though records prior to the 1919 acquisition by PG&E of the Battle Creek Hydroelectric Project are sparse, it appears that fish ladders were part of the original dam construction (PG&E 1998a). The first new construction under PG&E's purview was installation of a permanent ladder at Wildcat dam in 1925 (Figure 3). In 1928, work was also done on a fish ladder at North Battle Creek Feeder Dam. The ladder at Inskip Dam was extended in 1928 after high water washed away a rock shelf downstream of the dam and changed the channel configuration. In 1938, repairs and modifications were made at several sites following storms and floods in 1937. That work included replacement of the Coleman Dam fish ladder, replacement of the North Battle Creek Feeder Dam fish ladder, and repair and extension of the Eagle Canyon Dam fish ladder. No other significant work regarding ladders occurred until relicensing of the project in the mid-1970s.

During a 1966 survey of project facilities associated with project relicensing, CDFG documented conditions which suggested that salmon and steelhead likely did not have unimpeded access via fish ladders over PG&E diversion dams (Coots and Healey 1966). Though these ladders had been maintained, inappropriate ladder configuration and low flow releases likely impeded access at project fish ladders.

In approximately 1980, following receipt of the new FERC license for the project, PG&E, in consultation with CDFG, installed a new Alaskan steep-pass ladder on the right side of the Coleman Dam (PG&E 1998a). Soon after installation of the Coleman ladder, other ladders were modified in consultation with CDFG. Alaskan steep-pass or denil fish ladders were installed at North Battle Creek Feeder, Eagle Canyon, and Inskip dams in the mid-1980s. South Dam was completely replaced during the same period and a denil ladder was incorporated in the design. Following the modifications to the ladders in the 1980s, no further additions or changes have been made.

Fish ladders at Wildcat and Coleman dams were intentionally closed from 1986 to 1989 to manage the distribution of adult fall-run chinook salmon intentionally released upstream of the CNFH barrier dam during the period 1985 to 1989⁹ (CDFG 1993c; USFWS 1995a). The closure of fish ladders at Wildcat and Coleman dams during fall and early winter was initially undertaken by PG&E, at the request of USFWS, to protect the

⁹ Fall-run chinook were allowed over the CNFH barrier dam from 1985 to 1989, were allowed over Wildcat and Coleman dams in 1985, and were confined below Wildcat and Coleman in 1986 to 1989.

CNFH water supply¹⁰ (USFWS 1986b). This action was repeated from October 1 to December 31, 1988, again at the request of the USFWS “to prevent fall-run chinook salmon from gaining access into the upper tributaries of Battle Creek where they could contaminate Coleman Ditch and thus Coleman Hatchery with IHN virus” (USFWS 1988) and was formalized by FERC on July 25, 1988 (Anonymous 1989).

In the mid-1990s, similar actions were undertaken at Eagle Canyon¹¹ and Coleman dams, primarily to manage populations of spring-run chinook salmon and steelhead, though the justification for ladder closures was somewhat different (USFWS 1998e). The purpose for closing these ladders was “to limit the amount of stream available for spring-run chinook salmon and steelhead that may pass the recently opened ladder at the USFWS barrier dam at CNFH to prevent potential mates from being too widely distributed” (CDFG 1995a), to prevent entrainment into unscreened diversions, and to prevent passage to habitat having insufficient flows (USFWS 1997a; USBR 1998a). While the primary goals for these ladder closures was “to implement initial restoration phases of Battle Creek” a secondary reason was to “provide limited protection” to the CNFH water supply (USFWS 1998e). However, other more widely distributed literature emphasized the importance of closing these fish ladders as an interim measure to prevent anadromous fish from entering the CNFH water supply (USFWS 1997c). None-the-less, construction in 1999 of a new “ozone water treatment system [will alleviate] disease concerns associated with upstream passage of anadromous salmonids” (USFWS 1998f).

Fish Screens Within the Battle Creek Hydroelectric Project

As with fish ladders at the dams, fish screens appear to have been a feature of various canals or water diversions at, or soon after, original construction (PG&E 1998a). A 1920 project was authorized to replace original wood fish screen supports with concrete or masonry at Keswick, South, Eagle Canyon, Inskip, and South canals (Figure 3). This project also included addition of a screen in Union Canal upstream of the South Powerhouse forebay. Foundation work for fish screens was performed at various sites in 1922. A fish wheel, as the old screens were called, was installed at the head of North Battle Creek Feeder Canal in 1928. Other repairs and replacements using CDFG contemporary designs were performed over the years; the most recent repair on record was for the Inskip Canal screen in 1955. Fish screens were removed from the project prior to 1970.

¹⁰ Water diverted from Battle Creek at several points including Eagle Canyon, Wildcat, and Coleman Diversion dams, is conveyed in the Coleman Canal where the CNFH obtains a portion of its water (Figure 3). If infected fish migrate upstream of Wildcat and Coleman dams, the two lower-most dams in the watershed, then water-borne diseases could be conveyed in diverted water to CNFH through their intake on the Coleman Canal. If infected fish were prevented from migrating upstream of the two lower dams, then it would be expected that Coleman Canal would not convey water-borne diseases transmitted by fish migrating downstream of these two dams.

¹¹ By the mid-1990s, water was no longer being diverted at Wildcat Dam (USBR 1998a). Therefore, closing fish ladders at this dam could no longer be justified by concern for disease transmission from the Eagle Canyon reach to the Coleman Canal and the fish ladder at Wildcat Dam was kept open.

During the hydroelectric project relicensing process, various fishery issues were evaluated (PG&E 1998a). CDFG notified PG&E around 1970 that screening of their canal intakes was unnecessary (correspondence on file in PG&E archives). CDFG also advised USFWS in 1970, during the relicensing process, that there were indications of only minimal losses due to fish passage through the project powerhouses (CDFG 1970c). No screening was required as a license condition, despite the fact that anadromous fish were being entrained into project canals (CDFG 1965b), because efficient fish screens would ruin popular trout fisheries and trout habitat in the hydroelectric canals (Coots and Healey 1966; see also Resources Agency of California 1971b, which points out the need to screen penstock openings, as opposed to canal intakes, in order to protect trout populations residing in hydroelectric canals).

Recently, CDFG has issued new “Fish Screening Criteria” in an effort to coordinate with those of NMFS (CDFG 1997e) and have transmitted these criteria to PG&E (CDFG 1997f). NMFS further suggests that components of new fish passage facilities, including fish screens, should be constructed with rounded edges in streams with lamprey, because lamprey have difficulty moving around structures with angular edges (Ian Gilroy, NMFS, Eureka, California, pers. comm.).

Gravel Management

Gravel needed by spawning salmon in Battle Creek has been removed or rearranged on several occasions in the past. Considerable channel work for flood control has removed thousands of yards of spawning-size gravel from the lower reaches of the stream (CDFG 1970b, 1993a). Gravel trapped behind diversion dams higher in the watershed has been removed from the stream in the past (USRFRHAC 1989). Presently, PG&E removes gravel which accumulates upstream of their diversion dams when it interferes with operations. CDFG has requested that this gravel be placed downstream of the dams in order to maintain steady supplies of spawning gravel (CDFG streambed alteration permits, on file, Redding, California).

Fish Stocking and Sport Fisheries Management

In addition to fish releases associated with CNFH, CDFG has stocked the Battle Creek watershed repeatedly since 1940 (CDFG stocking records for Battle Creek on file at CDFG offices in Redding, California). Rainbow trout have been stocked in the North Fork at various locations annually since 1940, with the exception of 1947 and 1975, and in the South Fork at various locations annually since 1946. Brook trout have been stocked in the North Fork on at least five separate occasions, and in the South Fork annually since 1990 and two earlier occasions. Brown trout have been stocked in the North Fork repeatedly from 1961 through the mid-1990s and in the South Fork on two occasions in the mid-1940s. In 1995, CDFG officially ceased stocking anadromous waters of Battle Creek with hatchery trout.

Private parties currently stock small numbers of fish in the Battle Creek watershed with the approval of CDFG. One fishing resort stocks 400 sterile (triploid) rainbow trout

per year into the South Fork and another resort owner stocks rainbow trout into hydroelectric canals in the watershed. Neither stocked population is considered to seriously impact anadromous salmonids because the fish stocked in the wild are sterile,

because they are not likely to play a role in preventing the restoration of salmon and steelhead to Battle Creek.

Sacramento River Fisheries Management and Environmental Factors

Many fisheries management and environmental factors which affect Battle Creek fish populations, as well as populations from other Sacramento River tributaries, have been covered thoroughly in other documents. While it is out of the scope of this document to extensively address situations not specific to Battle Creek, this section will introduce these topics and provide references for further information.

Water diversions from the Sacramento River downstream of Battle Creek, including Red Bluff Diversion Dam and about 300 others, have been identified as causing problems for fish passage (CDFG 1990). Especially harmful for fish populations from the upper Sacramento River Basin are the many unscreened water diversions which can entrain juvenile and adult fish (CDFG 1990). Perhaps the most commonly cited factor negatively affecting populations of salmon and steelhead from Sacramento River tributaries such as Battle Creek is the operation of water pumping plants by State and federal agencies, as well as smaller water diversions, within the Sacramento/San Joaquin Delta (CDFG 1990). These pumps cause problems with the magnitude and direction of flow, tidal cycles, fish entrainment, salinity and water quality, and fish migration (CDFG 1990). The loss of riparian vegetation and functional changes to riparian habitat has contributed to the decline of fish populations in Sacramento River tributaries (CDFG 1993c). Water temperature (USBR 1991) and water quality problems in the form of mining pollution and turbidity (CDFG 1990) in the Sacramento River have been identified as negative factors for fish production. Hundreds of exotic species have been introduced to the Central Valley watershed that have, in some cases, such as striped bass (*Morone saxatilis*), impacted native fish assemblages, including salmon (Bay Institute 1998; Yoshiyama et al. 1998). Anthropogenic and natural global climate changes are expected to affect fish populations and should be considered when proposing management strategies for aquatic systems over long (decadal-scale) time periods (Regier et al. 1990; Magnuson et al. 1990, Francis 1993, and Smith 1978). Finally, long-term variability in many physical and biological oceanographic variables appears to be related to long-term changes in salmon production (Hollowed and Wooster 1991; Hare and Francis 1993; Ward 1993).

Summary of Past Restoration Efforts

Several previous efforts have been undertaken to develop plans and other institutional guidelines which would stem or reverse the conditions that are harmful to aquatic ecosystems in the upper Sacramento River basin (Table 6). In addition to many federal and State mandates designed to protect or restore fish populations and habitat (e.g. *Federal*: CVPIA, ESA. *State*: CESA, California Fish and Game Codes 1505, 1601, 1603, 5900 et seq., 5937, 6900 et seq., 1243, 1700, 2081, 2760; California Public Trust Doctrine, Fish and Game Commission Salmon Policy, Fish and Game Commission

Steelhead Policy, Fish and Game Commission Water Policy, Article 10, Section 2), specific legislative and agency initiatives have applied to ecosystems in Battle Creek.

The California Advisory Committee on Salmon and Steelhead Trout (CACSSST), created by the California legislature in 1970, led to a heightened awareness of the need for fisheries restoration that, in part, addressed fish populations in Battle Creek (CACSSST 1988; Table 6). For example, Hallock (1987) recommended that a salmon restoration plan be developed for Battle Creek upstream of the CNFH. He felt that the major factor suppressing salmon populations was decreased instream flows caused by the PG&E hydroelectric project and that restoration of stream flows could support populations of between 6,000 and 10,000 fall-run salmon, 2,500 spring-run salmon, and 1,000 steelhead.

During the same time frame, another group, the Upper Sacramento Fisheries and Riparian Habitat Advisory Council, established in 1986 by California Senate Bill (SB) 1086, generated a fisheries and riparian habitat management plan which also cited hydroelectric development, and the operation of the CNFH, as the two primary causes for low populations of naturally reproducing salmon and steelhead in Battle Creek (Table 6). This plan called for increased instream flows downstream of hydroelectric project diversions, installation of fish screens at project diversions, modification of the practice of removing gravel from behind project dams, increased release of salmon and steelhead upstream of CNFH, and the development of a specific anadromous fish management plan for Battle Creek and the CNFH.

In the early-1990s, another plan was developed to restore and enhance salmon and steelhead in the Central Valley (CDFG 1990; Table 6). This plan also called for increased instream flows and effective fish screens on Battle Creek. Also in the early-1990s, the Battle Creek Spawning Restoration Project, funded by Proposition 70, was completed. This project protected against bank erosion and channel migration which threatened important spawning riffles in lower Battle Creek and led to the purchase of riparian lands by CDFG (CDFG 1993a).

The final recommendations of the CACSSST were adopted in SB 2261, passed in 1988, which in turn led to the development of “A Plan for Action” (CDFG 1993c; Table 6) which called for increased instream flows, revised management of the barrier dam at CNFH, and the preparation and implementation of a comprehensive restoration plan for anadromous fish in Battle Creek. One offshoot of the “Plan for Action” was the development of the Steelhead Restoration and Management Plan for California which was designed to guide the CVPIA (CDFG 1996c).

Two new legislative initiatives, the Central Valley Project Improvement Act (CVPIA) of 1992 (H.R. 429 “Reclamation Projects Authorization and Adjustments Act of 1992: Title XXXIV – Central Valley Project Improvement Act”), and Proposition 204, were enacted in the 1990s and provided funds which have recently been used for fisheries restoration in Battle Creek (Table 6).

The CVPIA mandated changes in Central Valley Project (CVP) management in order to protect, restore, and enhance fish and wildlife habitat. In particular, the act stated “The mitigation for fish and wildlife losses incurred as a result of construction, operation, or maintenance of the Central Valley Project shall be based on the replacement of ecologically equivalent habitat” and that first priority shall be given to “measures which protect and restore natural channel and riparian habitat values.” To meet provisions of this act, the U.S Fish and Wildlife Service (USFWS) developed the Anadromous Fish Restoration Program (AFRP; USFWS 1997c) which identified 12 actions that would help restore anadromous fish to Battle Creek, including increasing instream flows past PG&E’s hydropower diversions and installing effective fish screens and ladders (Table 7).

Since 1995, instream flows in several reaches of Battle Creek have been increased above the minimum Federal Energy Regulatory Commission (FERC) flow requirements¹³ as part of two consecutive agreements between U.S. Bureau of Reclamation (USBR) and PG&E (CDFG 1995b; USBR 1996, 1998a, 1998b; Table 6). A partnership between PG&E, State and federal fisheries agencies, and restoration funding sources (CVPIA and Category III) allowed interim increases in flows at half of the hydroelectric diversions affecting salmon and steelhead while a permanent or long-term arrangement could be reached. These agreements have been referred to as the 1995 Interim Battle Creek Restoration Program (CDFG 1995b).

The “Bay-Delta Accord” created a framework (the CalFed Bay-Delta Program) for implementing conservation and restoration strategies, and stated that the signatories were committed to implementing and financing “Category III” measures to address non-flow factors as part of a comprehensive ecosystem protection and restoration plan (Bernard et al. 1996; Snow 1998; Chadwick-Darling 1998).

Contemporary Restoration Efforts

Without proper levels of funding, even the most well intentioned restoration effort is likely to fail. Unlike the previous restoration efforts which have largely demonstrated little results, the current Battle Creek restoration effort is expected to be the best hope for the stream dependent ecosystems of Battle Creek in the 20th century and for the foreseeable future because of the high level of funding available from CVPIA and Category III to remove environmental liabilities and to pay for improvements to the habitat (CalFed1998).

The BCWG was formed in 1997 in response to the continuing low fish populations and degraded habitat in Battle Creek (USRFHAC 1989), and in order to institutionalize restoration activities in Battle Creek funded by CVPIA and Category III (Table 1). In recognition of the short time-frame associated with CVPIA and Category III funding and the possibility of institutional inertia, a subgroup of the BCWG that did not include

¹³ FERC minimum instream flows for Battle Creek are currently 3 cfs for the North Fork and 5 cfs for the South Fork (U.S. Federal Power Commission 1976).

PG&E, released a working paper in January 1998 entitled “A Time For Action,” that was intended to catalyze the current planning process by suggesting a list of possible restoration actions (BCWG 1998). Biological, socio-economical, and political analyses have been conducted in response to this working paper. This present Restoration Plan is a result of these analyses. Furthermore, the Restoration Plan will support formal environmental documentation that will accompany the negotiated settlements.

Table 6. A timeline of restoration activities within Battle Creek, 1904 to 1998.

1904	<ul style="list-style-type: none"> An early fisheries worker for the US Fish Commission describes Battle Creek as one of the most important salmon streams in the Central Valley.
1962	<ul style="list-style-type: none"> Federal fisheries agency salmon planning effort recommends restoring natural streamflows throughout the Battle Creek system, primarily to meet the requirements for spring-run and winter-run chinook.
1965	<ul style="list-style-type: none"> California Fish and Game state wide fisheries planning effort recommends restoration and utilization of natural salmon spawning areas in throughout Battle Creek.
1987	<ul style="list-style-type: none"> California Advisory Committee on Salmon and Steelhead Trout (legislatively authorized in 1970) recommends restoring Battle Creek system.
1989	<ul style="list-style-type: none"> Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (Senate Bill 1086) called for increased instream flows and screens at hydroelectric project diversions and increased release of salmon and steelhead upstream of Coleman National Fish Hatchery while managing disease risks at the hatchery.
1990	<ul style="list-style-type: none"> California Fish and Game Central Valley basin planning effort for salmon and steelhead (Senate Bill 2261) makes recommendations to restore Battle Creek consistent with those in the 1989 SB 1086 process.
1993	<ul style="list-style-type: none"> California Fish and Game Central Valley fisheries restoration "Action Plan" (advisory to the Federal Central Valley Project Improvement Act of 1992) makes detailed recommendations to restore Battle Creek consistent with past recommendations on flow and passage.
1995	<ul style="list-style-type: none"> Technical teams from State and federal agencies develop advisory reports for Central Valley Project Improvement Act program restoration actions that include detailed recommendations to restore Battle Creek that are consistent with past recommendations on flow and passage. <ul style="list-style-type: none"> Partnership between PG&E, State and federal fisheries agencies and restoration funding sources (CVPIA and Category III) allows interim increases in flows at half of the hydroelectric diversions affecting salmon and steelhead while a permanent or long-term arrangement can be reached.
1996	<ul style="list-style-type: none"> <ul style="list-style-type: none"> CDFG Steelhead Restoration Plan advisory to the CVPIA of 1992 recommends increasing the instream flow at hydroelectric project diversion and allow steelhead to ascend above Coleman Fish Hatchery. 1996 Pacific Fisheries Management Council passes a resolution to examine the feasibility of reintroducing winter-run chinook into Battle Creek. Discussions regarding long-term fisheries restoration in Battle Creek commence between PG&E and resource agencies.
1997	<ul style="list-style-type: none"> <ul style="list-style-type: none"> National Marine Fisheries Service Proposed Recovery Plan for the Winter-run Chinook Salmon recommends conducting a feasibility analysis of reestablishing winter-run populations in Battle Creek. US Fish and Wildlife Service revised plan for implementing the Central Valley Project Improvement Act recommends more detailed actions to restore Battle Creek that are consistent with past recommendations on flow and passage. BCWG established by interested and affected parties associated with implementation of the Central Valley Improvement Act to develop an implementation plan for Battle Creek that is effective and has community acceptance. CalFed Category III contract for development of a comprehensive technical plan to guide implementation and receive advise from interested and affected parties. CalFed Category III / CVPIA Contract to foster development of a Battle Creek Conservancy through the joint efforts of the Western Shasta and the Tehama Resource Conservation Districts Battle Creek Watershed Conservancy is formed in the watershed and a newsletter is initiated.
1998	<ul style="list-style-type: none"> <ul style="list-style-type: none"> Battle Creek Work Group becomes a technical advisory committee for the technical plan developed under Category III grant. Working Group Subcommittees are convened to focus on biology, power loss and regulatory issues. Presentations are developed on alternative methods of providing flow and passage. CalFed Category III contract with CDWR to perform an engineering investigation of anadromous fish passage in upper Battle Creek. US Bureau of Reclamation Investigation on costs associated with decommissioning Wildcat, Eagle Canyon and Coleman Diversion Dams. Extensive development of technical information concerning the fisheries and economic aspects of restoring flow and passage in the foothill reaches of Battle Creek. Efforts by USFWS to develop a disease free water supply at CNFH enters its final construction phases. PG&E/CDFG make a joint presentation to the Battle Creek Watershed Conservancy on the scope of the Battle Creek Restoration effort. US Bureau of Reclamation prepared and circulated a Draft Environmental Assessment for the continuance of the temporary flow agreement augmenting streamflow in the lower half of Battle Creek. A second interim agreement allowing increases in flows at half of the hydroelectric diversions affecting salmon and steelhead is negotiated between PG&E, State and federal fisheries agencies, and restoration funding sources (CVPIA and Category III).

Table 7. Actions identified by the AFRP that would help restore anadromous fish to Battle Creek (USFWS 1997c).

Action																																								
1. Continue to allow adult spring-run chinook and steelhead passage above CNFH weir. Allow passage of fall- and late-fall-run chinook and steelhead above CNFH weir after disease-safe water supply becomes available to CNFH.																																								
2. Acquire water from willing sellers consistent with applicable guidelines or negotiate agreements to increase flows past PG&E's hydropower diversions in two phases to provide adequate holding, spawning, and rearing habitat for anadromous salmonids. The following suggested flows are indicators of magnitude and subject to revision based on additional analyses:																																								
<table border="1"> <thead> <tr> <th>Diversion</th> <th>Month</th> <th>Flow (cfs)</th> </tr> </thead> <tbody> <tr> <td>Keswick^b</td> <td>All year</td> <td>30</td> </tr> <tr> <td rowspan="3">N. B.C. Feeder^b</td> <td>Sept. – Nov.¹⁴</td> <td>40</td> </tr> <tr> <td>Jan. – Apr.</td> <td>40</td> </tr> <tr> <td>May – Aug.</td> <td>30</td> </tr> <tr> <td rowspan="2">Eagle Canyon^a</td> <td>May – Nov.</td> <td>30</td> </tr> <tr> <td>Dec. – Apr.</td> <td>50</td> </tr> <tr> <td rowspan="2">Wildcat^a</td> <td>May – Nov.</td> <td>30</td> </tr> <tr> <td>Dec. – Apr.</td> <td>50</td> </tr> <tr> <td rowspan="2">South^b</td> <td>May – Nov.</td> <td>20</td> </tr> <tr> <td>Dec. – Apr.</td> <td>30</td> </tr> <tr> <td rowspan="2">Inskip^b</td> <td>May – Nov.</td> <td>30</td> </tr> <tr> <td>Dec. – Apr.</td> <td>40</td> </tr> <tr> <td rowspan="2">Coleman^a</td> <td>Sept. – Apr.</td> <td>50</td> </tr> <tr> <td>May – Aug.</td> <td>30</td> </tr> </tbody> </table>			Diversion	Month	Flow (cfs)	Keswick ^b	All year	30	N. B.C. Feeder ^b	Sept. – Nov. ¹⁴	40	Jan. – Apr.	40	May – Aug.	30	Eagle Canyon ^a	May – Nov.	30	Dec. – Apr.	50	Wildcat ^a	May – Nov.	30	Dec. – Apr.	50	South ^b	May – Nov.	20	Dec. – Apr.	30	Inskip ^b	May – Nov.	30	Dec. – Apr.	40	Coleman ^a	Sept. – Apr.	50	May – Aug.	30
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^a First phase flows required to support winter- and spring-run chinook salmon between the Coleman Powerhouse and Eagle Canyon Diversion dams while a disease-safe water supply is being developed for CNFH.																																								
^b Second phase flows required to support fall-run chinook salmon and steelhead above the CNFH weir, Coleman Powerhouse and Eagle Canyon Dam, after a disease-safe water supply is available to CNFH.																																								
3. Construct barrier racks at the Gover Diversion dam and waste gates from the Gover Canal to prevent adult chinook salmon from entering Gover Diversion.																																								
4. Screen Orwick Diversion to prevent entrainment of juvenile salmonids and straying of adult chinook salmon.																																								
5. Screen tailrace of Coleman Powerhouse to eliminate attraction of adult chinook salmon and steelhead into an area with little spawning habitat and contamination of the CNFH water supply.																																								
6. Construct fish screens on all PG&E diversions, as appropriate, after both phases of upstream flow actions (see Action 1) are completed and fish ladders on Coleman and Eagle Canyon diversion dams are opened.																																								
7. Improve fish passage in Eagle Canyon by modifying a bedrock ledge and boulders that are potential barriers to adult salmonids, and rebuild fish ladders on Wildcat and Eagle Canyon diversion dams.																																								
8. Screen CNFH intakes 2 and 3 to prevent entrainment of juvenile chinook and steelhead.																																								
9. Evaluate the effectiveness of fish ladders at PG&E diversions.																																								
10. Evaluate the feasibility of establishing naturally spawning populations of winter-run and spring-run chinook salmon and steelhead through a comprehensive plan to restore Battle Creek.																																								
11. Evaluate alternatives for providing a disease-safe water supply to CNFH so that winter-, spring- and																																								

¹⁴ The original table of flows in the AFRP document neglected to specify flows at North Battle Creek Feeder in December.

fall-run chinook salmon and steelhead would have access to an additional 41 miles of Battle Creek habitat.
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12. Develop a comprehensive restoration plan for Battle Creek that integrates CNFH operations.
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As summarized earlier in this document, several previous restoration plans had suggested that changes in the operations of the Battle Creek Hydroelectric Project would constitute the most critical restoration actions to be undertaken in the effort to restore anadromous salmonids to Battle Creek (CDFG 1990; USFWS 1997b). Prior to formation of the BCWG in 1997, some of the previously suggested actions were being implemented, at least in part. However, long-term comprehensive and effective restoration actions still needed to be implemented.

For example, FERC minimum instream flows for Battle Creek are currently set at 3 cfs for the North Fork and 5 cfs for the South Fork (U.S. Federal Power Commission 1973) for “the purpose of maintaining aquatic life below project diversions” (Resources Agency of California 1971a). In order to enhance current fish populations, the AFRP called for increased instream flows in the project area at levels from 4 to 17 times the FERC minimum flows (USFWS 1997c). Though interim actions included temporary increases in instream flows downstream of Eagle Canyon and Coleman dams and cessation of diversions at Wildcat Dam (USBR 1996), these actions were recognized by the BCWG as providing less than full, long-term, comprehensive restoration.

The BCWG undertook a consensus approach, open to all stakeholders, that was directed at developing a workable range of options. The range of suggested changes to the Battle Creek Hydroelectric Project had spanned from “no action” to complete decommissioning of the entire project. This wide range of alternatives was narrowed through the stakeholder process. The elimination of the hydroelectric project was determined to be undesirable by the BCWG. Alternatively, specific mandates for the recovery of species jeopardized with extinction, and a desire to have healthy wild salmonid populations, determined that “no action” was also not desirable.

The resultant recognition was that ecosystem restoration in the vicinity of the Battle Creek Hydroelectric Project, while staying clear of the far ends of the spectrum of alternatives, would consider a middle range of alternatives that maintain a balance between hydropower production and effective recovery of biological resources. The presence of natural barrier falls which impede anadromous fish passage, on both the North and South forks, assisted in helping to achieve this balance. There are six main hydropower dams and three diversion dams on tributary streams which require increased instream flow releases and/or other protective measures. Alternate plans consider the possibility of decommissioning some project facilities in order to maximize certainty of achieving biological effectiveness and based on the economic viability of specific installations following initiation of higher instream flows or other proposed water conveyance modifications.

Several actions were taken by the BCWG and its constituents to further narrow the scope of restoration alternatives. For example, the USFWS initiated several improvements to facilities at the CNFH as specified in the AFRP (USFWS 1997b). Construction of a water treatment facility was initiated by the USFWS to secure a disease-

safe water supply to the hatchery (Sverdrup 1986, 1989; USFWS 1997d, 1997e). Water supply intakes to the CNFH are being improved with fish screens and plans for an interim tailrace barrier at the Coleman Powerhouse are being developed (USBR 1998a). CDFG has also screened diversion in Battle Creek including the Gover and Orwick diversions. Finally, the USFWS, CDFG, and local watershed groups, have increased public outreach and fisheries interpretation through implementation of the Salmon Festival and development of facilities in the Battle Creek Wildlife Area (USFWS n.d.).

Other agencies also took actions which further narrowed the scope of restoration alternatives. The USBR and PG&E are negotiating a second interim agreement to increase instream flows in Battle Creek (USBR 1998a). The Tehama County Resource Conservation District (TCRCD) and Shasta County Resource Conservation District (SCRCD) received a 1996 CalFed/CVPIA grant to fund the Battle Creek Watershed Project (BCWP). This project provided timely information regarding watershed restoration efforts to the Battle Creek Watershed Conservancy (BCWC) and the larger landowner community.

The BCWC took shape in early-1998 among the basin's landowners. Created initially as a means of sharing information among watershed residents about the salmon and steelhead restoration plans under development by State and federal agencies, the BCWC soon began to discuss other matters of concern to local landowners, including education, upper watershed processes, solid waste management, exotic vegetation control, and fire safety. By summer, watershed residents had reached sufficient agreement among themselves to make an application for grant funds with which to address their priorities.

The BCWC monitored the work of the BCWG closely during 1998. As the scope and potential cost of the proposed salmon and steelhead restoration program became clear during the year, BCWC representatives pointed out that the BCWG's planning blithely assumed a continued supply of good quality water from the upper watershed. Suggesting that it would behoove the salmon and steelhead restoration program planners to consider the factors affecting streamflow and water quality above the restoration reaches, the BCWC helped organize a tour of stream restoration efforts underway on the Battle Creek Meadows Ranch in early summer. The BCWC supports efforts to restore salmon and steelhead in Battle Creek and has made a solid case that the entire watershed, not just the anadromous fish restoration reaches, deserve the attention and concern of the salmon and steelhead restoration community.

In addition to these specific actions, agency members of the BCWG received CalFed, USBR, and other funds to 1) investigate the costs of decommissioning three project facilities including Wildcat, Coleman and Eagle Canyon dams, 2) investigate the costs of installing fish passage facilities (screens and ladders) at each PG&E diversion, 3) investigate the cost of installing conduits for directing powerhouse tailrace discharges to project canals in order to reduce straying of adult salmon caused by inter-basin transfers of water, 4) examine available biological information to recommend a biologically-optimum flow regime below PG&E diversions, 5) determine of the costs of foregone hydropower under various possible flow regimes, 6) consult with the BCWC representing the interests of the local people residing within the watershed, 7) consider the effects of recent

deregulation of the electric generation industry on the future ownership of the Battle Creek Hydroelectric Project, 8) determine procedures necessary to ensure full regulatory compliance and environmental documentation with any actions taken, and 9) complete the water treatment construction at CNFH.

TECHNICAL PLAN

Introduction

This section introduces the goals of the present restoration efforts by the BCWG, discusses existing conditions in five key areas of the Battle Creek watershed, analyzes ecosystem processes limiting salmon and steelhead when sufficient data exists, and describes restoration objectives for each area. The five geographical areas under consideration include: 1) the Battle Creek uplands which includes the land surrounding the anadromous reaches of Battle Creek; 2) Battle Creek upstream of anadromous fish habitat, which includes terrestrial and aquatic habitats interacting with Battle Creek upstream of river mile river mile 13.48 on the North Fork and river mile 18.85 on the South Fork, the locations of barriers defining the distribution of anadromous salmonids in Battle Creek; 3) the anadromous reaches of Battle Creek downstream of river miles 13.48 and 18.85 on the North and South forks, respectively, but upstream of CNFH; 4) CNFH; and 5) Battle Creek downstream of CNFH.

Goals of Battle Creek Restoration

Anadromous Salmonids and Ecosystem Function

Anadromous salmonids, including chinook salmon and steelhead, are the focus of this restoration effort largely due to cultural and economic motivating factors that have also been evidenced in previous fisheries management and restoration programs. In addition, salmon and steelhead can function as indicator species that provide a view of the health of the overall ecosystem.

The leading contemporary drivers of fisheries restoration in Battle Creek, namely CalFed (CalFed 1998) and CVPIA, both call for an ecosystem approach to salmonid restoration. While these mandates stop short of requiring that entire ecosystems be fully restored, including, say, all populations of every plant and animal in that biological community, CalFed and CVPIA specify that restoration actions undertaken for the benefit of salmon and steelhead should address ecosystem functions or processes. These legislative mandates recognize that effective long-term species protection mandates “preventative rather than reactive management, and a focus on landscapes rather than populations” (Angermeier and Karr 1994). Hence, this Restoration Plan attempts to follow CalFed and CVPIA guidelines to the extent possible when recommending restoration actions.

The “ecosystem level” approach can be contrasted with the “species-level efforts” (Bay Institute 1998):

An ecosystem-level approach to restoration refers to efforts primarily aimed at identifying and addressing, in the aggregate, suites of key attributes (both biological and abiological) of spatially defined areas. This fundamentally differs

from species-level efforts, which instead are based upon attempts to identify and address the “limiting factors” of particular species (Bay Institute 1998).

Ecosystem-level approaches are superior to single-species approaches because they are designed to provide protection for a wide variety of species and protect species or physical processes about which little is known (FEMAT 1993; Spence et al. 1996; Bay Institute 1998). However, single-species restoration actions can be used within broader approaches to target specific species needs (Bay Institute 1998).

Spence et al. (1996) elaborated on these principles by defining essential goals for salmonid restoration, including improvement of connectivity between isolated habitat patches, and protection and restoration of areas surrounding critical refugia from further degradation, so as to allow for the expansion of existing populations. This idea of protecting refugia, habitats with the highest degree of integrity and centers from which population expansion can occur, is stressed by many other conservation strategists (Moyle and Sato 1991; Doppelt et al. 1993; Frissell et al. 1993; Henjum et al. 1994; Bradbury et al. 1995). Refugia have even more importance in relation to the preservation of endangered species. Soulé (1986) stated, and Reiman et al. (1993) emphasized with fisheries examples, that the probability of extinction of a species decreases with the increase in numbers of self-sustaining populations in independent habitats. That is, extinction is best prevented by maintaining strong populations in the best possible habitats (Reiman et al. 1993).

One example within Battle Creek of the difference between potential species-level restoration and ecosystem-approaches can be illustrated with the case of South Fork Battle Creek. A fully functioning stream draining the southern Cascade mountains in the vicinity of Battle Creek would be expected to arise in steep, mountainous terrain as small, cool, spring-fed creeks. As the stream flows downstream from its headwaters crosses meadows and cuts through canyons gradually reducing in gradient as it finally becomes a meandering stream on the valley floor. The stream’s flow and channel size increase as it collects more tributaries, springs and groundwater as it flows downhill. The form and function of aquatic habitats gradually change as the stream flows downhill with cooler, more compact habitats found in the higher elevation reaches and larger, warmer habitats in the lower elevation reaches where the channel width is greater and the climate is warmer. Fish species, such as spring- and winter-run chinook, are obligated to habitats dominated by cold water springs or cooler high elevation climates because their temperature-sensitive life stages inhabit the stream during warm seasons. Fish like fall-run chinook salmon and steelhead, take another approach to temperature and habitat constraints; they spawn in the fall when seasonal changes in water temperature afford cool water for spawning and egg incubation.

In its present form many of the key natural processes and ecosystem functions of South Fork Battle Creek have been critically altered by land and water use in the watershed. South Fork Battle Creek rises on the slopes of Mt. Lassen. However, the upper reaches flow through large meadows near the town of Mineral that no longer have thick vegetation on the stream banks and have channels that have downcut into the

meadow, diminishing the meadows ability to provide large amounts of cold groundwater during the warm season. As the South Fork enters a long canyon area, it collects groundwater and runoff from a series of abundant springs that reduces, even during drought conditions, the usual warming experienced by most streams as they decrease in elevation.

There are a series of diversions (South, Inskip, and Coleman dams) in this canyon area that reduce the instream flow to less than 10 percent of the natural flow during the summer, thereby significantly reducing the available coldwater aquatic habitat and isolating reaches kept cold by major spring accretions. These diversions do not allow safe downstream movement of fish because they are not screened. They also impair upstream passage for fish that migrate during the wet season because the ladders are only sized to be effective during dry season flows (5 cfs). In addition, two major tributaries to the South Fork in the canyon reach (Soap and Ripley creeks) have diversions that take all the natural flow. Therefore, aquatic habitat at these points is disrupted and fish movement is restricted. The Soap Creek diversion receives water from an exceptionally large cold-water spring called Bluff Springs, thereby preventing this cold water from reaching the stream until the diversion rejoins the creek at a lower-elevation powerhouse.

The powerhouses in the canyon reach also mix water diverted from the North Fork with South Fork water in amounts that cause the chemical characteristics of the mixture to be dominated by those specific to the North Fork. Significant changes in the characteristics of the water can confuse migratory fish, such as salmon and steelhead, that seek out their natal stream based upon chemical cues that are present at very low concentrations. Falsely attracting migratory fish to low-elevation reaches of the South Fork, dominated by powerhouse tailrace waters, can prevent them from reaching the favorable, stable habitats in the upper North Fork and upper South Fork. Compared to existing conditions, eliminating the mixing of the tailrace water from the North Fork with the South Fork, while restoring streamflows, avoids the adverse affects of false attraction without causing significant adverse affects for any of the native fish species. Although the tailrace waters can cool off isolated reaches of the South Fork, these reaches are small relative to the entire system and are of lower quality than those found in the North Fork and in the higher-elevation reaches of the South Fork, where the climate and the water is cooler. In addition, the habitats influenced by the tailrace waters are not as stable as those in the natural stream due to interruptions in tailrace water caused by powerhouse and canal outages. False attraction is especially detrimental to winter-run chinook salmon because the most stable drought resistant habitat in the restored system will be in the North Fork and it is important that this population has high spawning fidelity to the reach of the stream having the highest value for conservation of the species.

A single-species approach focused on salmon that has been suggest for the South Fork assumes that improved fish ladders and screens at diversion dams would solve the upstream and downstream passage of salmon. Also, continuing the transbasin diversion of North Fork water to the South Fork has been suggested as a mechanism for intentionally cooling the lower-elevation reaches of the South Fork to add habitat for rearing steelhead trout in a portion of the two-mile long Coleman reach. However, this single-species

approach does not restore the ecosystem processes of unimpeded water flow, does not restore the thermal gradients and thermal regime of cool water that provides the environmental cues to partition fish species to stable habitats, and still continues to provide a source of confusion for migrating salmonids that are keyed into odors from the North Fork. Artificial, cool-water areas downstream of powerhouses are small relative to the entire South Fork system, and are at lower elevations where the climate is hot and topographical shading is lacking, causing rapid heat gain. More importantly, these isolated reaches are susceptible to possible powerhouse or canal shutdowns, which would deny the source of the cold water and could strand fish and developing embryos in water that is warmer than where they would otherwise reside. Furthermore, under a restored flow regime, steelhead rearing habitat would become plentiful throughout the Battle Creek watershed (13.5 miles in the North Fork and 16.31 miles in the South Fork upstream of Coleman Dam), in addition to steelhead rearing habitat that already exists in 15.2 miles of Battle Creek downstream of the confluence and in nearly 70 miles of the Sacramento River between Battle Creek and Chico, California (CDFG 1997g; water temperature data for Sacramento River from California Data Exchange Center), so the addition of less than 2 miles of habitat in the Coleman Reach would be an insignificant enhancement. Finally, depending on mechanical systems to deliver cool water from water diversions on the North and South forks to reaches downstream of powerhouses violates Cairns' (1990) recommendations that restoration actions need to be ecologically stable and should not be prone to design failure and unpredictable breakdowns characteristic of all mechanical systems including powerhouses and conveyance facilities.

This single-species approach is also flawed because it maintains diversion totaling about 800 cfs that would need to be screened, with some of the water needing to be screened three times. Each screening operation will be susceptible to mechanical failure primarily due to debris and destruction from severe flood conditions. For example, the hydroelectric project was previously screened but the screens were destroyed by floods and there were no funds to replace them.

On the other hand, an approach designed to restore natural ecosystem function might include possible restoration actions such as decommissioning and removal of dams, the installation of facilities that prevent mixing of North Fork water with the South Fork, release of spring-water to the stream, and increasing instream flows. Decommissioning and removing dams on the South Fork would alleviate fish passage problems and meet the goal of avoiding unpredictable mechanical failures associated with screens and ladders. Removal of dams in the upper stream reaches would also serve to provide to fish the maximum amount of water and coolest temperatures naturally available. The installation of facilities that prevent mixing of North Fork water with the South Fork, especially installation of facilities which prevent the mixing of all powerhouse tail-race water, would serve to prevent false attraction of fish seeking the North Fork and would prevent the false attraction of fish using the artificial, cool reaches of water that presently form downstream of powerhouses.

An ecosystem approach would change some key features of the system relating to ecosystem function that are not considered in the single-species approach. Most

importantly, flow should be restored in amounts and times needed to provide habitat, restore temperature gradients, and provide connectivity between the various habitats in the stream that are sometimes separated by natural barriers, especially at low flows. Biological resources would receive the further benefit of safe passage throughout the stream system by minimizing the amount of fish screens and ladders required. This can be accomplished using two methods: 1) dams can be removed that contribute small amounts of hydropower relative to the whole system once the requisite streamflows are restored, and 2) powerhouse tailraces can be directly connected to downstream diversion canals to reduce the amount of screening needed. Eliminating lower-elevation dams, such as Coleman Dam, is especially important when species with life history strategies that include adult summer residence (e.g. winter- and spring-run chinook) need to reach cold, drought-resistant habitat at higher elevations. Eliminating summer-time diversions on Soap Creek would allow the large volume of spring water from Bluff Springs to reach the South Fork and restore the function of this tributary. The installation of connectors between powerhouses and downstream canals would restore a primary ecosystem characteristic of separating North Fork water from the South Fork upstream of the natural confluence of these two streams. This method would maximize the fidelity of North Fork fish populations to their natal stream reaches which are stable and which reliably provide all their life history requirements. Finally, by eliminating the artificial infusions of waters having different physical and chemical characteristics, the stream will maintain even thermal gradients that serve to partition fish species to their preferred habitat and provide the environmental cues need for aquatic life to move to their preferred reaches at the right times (Spence et al. 1996)

When chinook salmon and steelhead are examined separately, some specific goals for their restoration can be discussed in terms of the overall ecosystem. The CVPIA mandated a program to double the natural production of anadromous fish in Central Valley rivers and streams (USFWS 1995a). In Battle Creek, it has been recognized that modest improvements in the habitat could restore populations of chinook and steelhead to levels much greater than double the current levels. For instance, USFWS (1995a) provided a prospectus based upon minimally achievable restoration actions, including increases in flow and improved fish passage facilities, that could increase salmon and steelhead populations by approximately 19,700 fish over existing populations (Table 8). As explained in Cairns (1990), predictions of restored population sizes improve as the restored ecosystem more closely approximates the original condition. Therefore, these predictions would be more accurate, and perhaps higher, if more extensive ecosystem restoration actions are undertaken.

Table 8. Predicted population sizes of chinook salmon and steelhead in Battle Creek after implementing restoration measures outlined in USFWS (1995a).

Battle Creek Anadromous Fish Populations	Increases (in numbers of adult fish)
Winter-run chinook salmon	2,500
Spring-run chinook salmon	2,500
Fall-run chinook salmon	4,500
Late-fall-run chinook salmon	4,500
Steelhead	5,700
Total	19,700

Specifying target population sizes for individual species, however, is perhaps a misleading way of determining restoration goals (Bay Institute 1998). For instance, the predictions in USFWS (1995a) were based on specific restoration actions which may be exceeded in breadth and scope. Conversely, determining the number of salmonids, non-salmonid fishes, amphibians, aquatic macroinvertebrates, bald eagles, and Valley elderberry longhorn beetles, not to mention the hundreds of other stream-dependent animals and plants, that are desired or expected after complete restoration of Battle Creek, is fraught with too much scientific uncertainty to make the predictions meaningful. However, it can be expected that restoration actions chosen to create the right ecological opportunities will result in biological outcomes that reasonably approximate past conditions within the Battle Creek ecosystem (Berger 1990). The goal for species listed under either State or federal endangered species acts should be recovery according to criteria in relevant recovery plans.

Stream-Dependent Economic Values

There are presently several industries dependent on values related to streams and water within Battle Creek, not to mention the cascading economic benefits associated with these industries. Some of these industries include hydroelectric power generation and the users of hydroelectric power, commercial fishing, agriculture dependent on irrigation using surface waters, and recreation including fishing clubs and guide services. Although it has been recognized that modifications to the Battle Creek Hydroelectric Project must occur under a successful restoration program, steps will be taken to minimize the economic impact on this project and to insure the project's viability. Furthermore, the seven other existing or proposed hydroelectric projects will likely not be affected by a successful restoration plan because they are located outside the anadromous fish reaches. Similarly, current restoration planning does not intend to change any consumptive water rights within the Battle Creek watershed and would not impact existing agriculture. Increases in fish populations, on the other hand, should benefit recreational industries including fishing clubs and guide services, as well as commercial fisheries, by providing more fish to catch. However, commercial and sport fisheries will likely continue to operate under strict fishing regulations until species listed under federal and State endangered species statutes are fully recovered.

“Maximum Potential Restoration”

Several analytic tools used in this Technical Plan section consider ecological characteristics (e.g. habitat descriptions, species prioritization, and temperature regimes) that would be achieved under "maximum potential restoration" or similar terms like "complete" or "full" restoration. In general, these tools are used to set targets for what could be achieved if every identified problem affecting anadromous salmonids could be fixed. Due to the reality of limited restoration funds, the stated goal of balancing restoration with stream-dependent economic values, and other socio-political realities, we acknowledge that not all possible restoration actions will be implemented as a result of this Restoration Plan. However, these compromises are best addressed in the recommendations and subsequent restoration actions, rather than to bias the tools used to evaluate the potential for restoration. Therefore, tools used in this planning document consider the maximum potential for restoration, unless they are specifically identified otherwise.

Battle Creek Uplands

A description of the land use and foreseeable future management of land within the Battle Creek watershed will be described in a report currently in preparation by the BCWP. In light of the forthcoming information in the BCWP report, the present Restoration Plan will just briefly describe land use in the Battle Creek watershed and how it could affect the restoration of salmon and steelhead.

At present, private land adjacent to the anadromous reaches of Battle Creek, referred to here as the “Battle Creek uplands,” is managed by relatively few landowners for agriculture and cattle grazing. Historically, these few landowners have either intentionally or fortuitously protected the anadromous reaches of Battle Creek from human disturbance by limiting access to the large tracts of land in their ownership and by focusing land management on areas away from the stream. The geology of the lower Battle Creek watershed, where the stream cuts through a basalt plateau in deep, steep sided canyons, has also helped minimize interactions between the anadromous portion of Battle Creek and the surrounding uplands. Therefore, no significant existing threats to salmon and steelhead restoration have been identified in the upland areas.

For instance, no large scale timber harvesting, a factor often identified as impacting salmonid populations (e.g. Spence et al. 1996), occurs within the anadromous portion of the watershed. The few roads which exist in the watershed are generally well outside the stream corridor; modern bridges and maintained pavement minimize negative affects of roads at the few stream crossings that do exist. Also, sediment-laden runoff from the uplands has not been identified as a problem for Battle Creek because the basaltic nature of the watershed has prevented the accumulations of erosion-prone soils.

Though present interactions between the uplands and the stream are limited, several potential changes in land management could occur which might threaten salmon and steelhead in the future. The future of the large, private landholdings that currently act

as a buffer between human land use and Battle Creek is uncertain. First, efforts are currently underway to convert some private land along the mainstem of Battle Creek into publicly owned land (BLM 1998). The BCWC and local landowners have opposed this process and have predicted that increased public ownership in the watershed will lead to increased public access and likely heightened human impacts on sensitive populations of salmon and steelhead (R. Lee and B. McCampbell, presentations to the BCWG, 1998). Increased fishing pressure, poaching, and disturbance of holding or spawning salmon and steelhead are actions which could delay or impede restoration of salmon and steelhead. Even casual use of Battle Creek for seemingly-innocuous recreational activities like swimming or rafting could harm salmon and steelhead (Ward 1988; Moyle 1993).

Demographic changes within the watershed also call to question the future existence of large, private land holdings buffering Battle Creek. Large land holdings in Battle Creek have historically remained within certain families from generation to generation. This cohesive, vertical transfer of land may be disrupted due to changing economics associated with agriculture and grazing, increasing costs (e.g. property taxes) associated with owning large pieces of land, and changing personal attitudes of younger-generation residents of Battle Creek (several anonymous residents of Battle Creek, pers. comm.). Current trends throughout the American West indicate that as the economics within Battle Creek shift and as more people seek land in rural areas, it is likely that large land holdings will be subdivided and sold to multiple owners (Rudzitis 1996; Power 1996) leading to more complicated political and land management scenarios which will likely impact the ability to restore or maintain salmon and steelhead populations. The present land use and ownership patterns have been identified by CDFG as the best for the restoration of anadromous fish populations compared with the identified alternatives (CDFG 1997d).

Water pollution from both point and non-point sources in the uplands, has not been previously identified as a problem in Battle Creek. However, these factors have been identified in other rural/agricultural areas as affecting salmon populations (e.g. KRBFTF 1991; ORCD, in preparation). Shifts in agricultural crops and suburbanization of the watershed could likely cause pollution concerns in the future, as well as potential impacts on surface and groundwater usage.

Catastrophic wild fires in the uplands surrounding the anadromous fish habitat of Battle Creek have also been identified as a major concern by the BCWC (R. Lee presentation to the BCWG, 1998). Currently large populations of noxious weeds and other brush have created high fuel loads within the Battle Creek watershed. Though limited topsoil exists within the watershed, large fires could devegetate vast areas of land exposing significant amounts of soil to erosive processes which might then carry the sediment to fish habitat in Battle Creek (Wissmar et al. 1994; see Spence et al. 1996 for a review of the effects of wildfires on salmonids). Chemical fire retardants needed to suppress wild fires have also been identified as impacting water quality and killing fish (Norris and Webb 1989).

Battle Creek Upstream of Anadromous Fish Habitat

There are approximately 16 miles of North Fork Battle Creek and 10 miles of South Fork Battle Creek upstream of anadromous fish migration barriers in the Battle Creek watershed. Many more miles of streams tributary to the two forks of Battle Creek also exist in this portion of the watershed. The headwaters of Battle Creek are predominately on public lands with the majority originating on LNF or Lassen National Volcanic Park.

In general, the stream systems of the upper watershed are in good health; fisheries, water, and land management activities occurring in these streams have little impact on the potential to restore anadromous salmonids to the lower Battle Creek watershed (Terry Healey, District Fisheries Biologist, CDFG, Reading, California, pers. comm.; Susan Chapelle, Forest Fisheries Biologist, LNF, Susanville, California, pers. comm.; Mike Kossow, Fisheries and Biological Specialist, Meadowbrook Conservation Associates, Taylorsville, California, pers. comm.). Several fisheries, land, and water management actions in the upper watershed affect resident populations of fish but these effects are usually localized and attenuated by the time Battle Creek flows into anadromous fish habitat. Some of these actions include fish stocking in streams and reservoirs of the upper watershed for recreational fishing, timber harvest on private and public lands primarily in the headwaters areas, cattle grazing in or near riparian ecosystems, and hydroelectric power development.

One water management activity in the upper watershed that may affect anadromous fish habitat is the use of surface water for agriculture. Though the quantity of water diverted from tributaries to Battle Creek has been disputed in the past, usually among private water rights holders, and is considered to be an issue outside of the scope of this restoration plan, particularly because the amounts of water involved are of little concern to the restoration of salmon and steelhead in the lower watershed, water quality and temperature impacts may affect anadromous fish habitat.

Lassen National Forest manages a total of 21 percent of the entire Battle Creek watershed although Forest lands encompass only the headwater areas above approximately 4000 foot elevation. LNF provides for multiple use with an emphasis on maintaining and restoring ecosystem function and health (USFS 1992a). The Battle Creek watershed was not proposed for Key Watershed designation by the USFS because National Forest lands are well upstream of available anadromous habitat and downstream water users appear to play a key role in the restoration potential for anadromous fish in this watershed, despite the fact that these watersheds contain ESA-listed anadromous fish (USFS 1997).

In a biological assessment that focused specifically on ESA-sensitive species (USFS 1997), the USFS determined that actions proposed in the Lassen National Forest Land and Resource Management Plan (USFS 1992b) would not affect winter-run chinook salmon or its designated habitat, and may affect, but was not likely to jeopardize, steelhead or spring-, fall- and late-fall chinook salmon in Battle Creek. Although forest management

activities were acknowledged to influence water quality and water quantity, positive or negative effects would be buffered by 1) the distance separating the boundaries of the National Forest from designated critical habitat, 2) the presence of numerous off-forest water diversions on most tributaries, and 3) other tributaries which contain large reservoirs downstream of LNF lands (USFS 1997). However, USFS (1997) did not appear to consider the cumulative effects of forest management influence on water quantity in relation to the downstream water uses cited above. Furthermore, this biological assessment was written in reference to populations of winter-run chinook salmon inhabiting the Sacramento River and not those in a restored Battle Creek. On the other hand, the findings of “may affect, but not likely to jeopardize” concluded for steelhead and other races of chinook salmon would likely also apply to Battle Creek populations of winter-run chinook salmon.

These discrepancies were addressed in a 1998 addendum to the biological assessment (USFS 1998). During Section 7 consultation between USFS and NMFS (as required by the ESA), the LNF recognized the need to treat Battle Creek as a key watershed (NMFS 1998). This recognition will include management direction equivalent to designated key watershed status under PACFISH (USFS and BLM 1995), including priority for watershed analysis, maintenance and restoration projects, and Riparian Habitat Conservation Area management direction for category 1,2,3, and 4 streams and water bodies. In addition, the LNF will revise its long term monitoring plan to include stream reaches in the Battle Creek watershed.

Private lands in the upper watershed, like the uplands of the anadromous portion of the watershed, are divided into relatively few, large parcels owned by few individuals. However, unlike the anadromous portion of the watershed, land management activities such as cattle grazing have not been historically separated from riparian and stream ecosystems. Indeed, cattle grazing and timber harvesting have been shown to negatively affect fish populations and fish habitat in upper Battle Creek (CDFG 1968, 1969; Mike Kossow, Meadowbrook Conservation Assoc., Taylorsville, California, pers. comm.). However, the effects that these activities have on Battle Creek are localized and are likely attenuated by the time the stream reaches anadromous fish habitat.

Most importantly, private landowners in the upper watershed have been voluntarily taking proactive steps to restore streamside riparian areas and fish habitat. For example, the owners of the Battle Creek Meadows Ranch, a property of 2,200 acres that comprises a large portion of the private land in the upper South Fork Battle Creek watershed, have been taking significant steps to address degraded riparian areas and stream morphology on their property (Mike Kossow, Meadowbrook Conservation Assoc., Taylorsville, California, pers. comm.). In the 1940s, riparian vegetation was removed, under the encouragement of federal programs, to increase agricultural output. This action, coupled with cattle grazing in riparian areas, led to dramatic changes in stream morphology including dramatic widening of the stream channel, a decrease in functional meadow area, elimination of most pool habitat, and elimination of instream and riparian cover. In recent years, the owners of the Battle Creek Meadows Ranch have: 1) developed restoration strategies to restore their segment of Battle Creek; 2) conducted fisheries and habitat

surveys; 3) implemented riparian plantings and bank stabilization measures, and 4) begun to implement selective fencing to separate cattle grazing from the most sensitive portions of the stream. These actions, if they are continued and, especially, if they are adopted by other land owners, will ensure that the effects of upper-watershed land-use on private lands will have minimal affect on anadromous fish populations and habitat. Again, the present land use and ownership patterns in the upper watershed have been identified by CDFG as preferable for the restoration of anadromous fish populations compared with identified alternatives (CDFG 1997d).

Though little or no negative impacts on the restoration of anadromous salmonids stemming from fisheries, water, and land management in the upper Battle Creek watershed have been identified, in part because of geological and geographical conditions, a contributing factor has been the relative lack of scientific attention afforded to the upper watershed. Several investigations and preventative restoration measures should be considered in order to maintain current levels of protection and to prevent future upper-watershed impacts to anadromous fish populations and habitat.

Knowledge of sediment sources and routing in the upper watershed is lacking primarily due to the fact that no comprehensive watershed assessment has been performed. The USFS is currently performing a landscape analysis, which has identified roads and rhyolitic soils in the uppermost portion of the watershed as areas of concern to the USFS (Ken Roby, LNF, Susanville, California, pers. comm.), but this study does not consider private lands (Susan Chapelle, LNF, Susanville, California, pers. comm.) and may have functional differences from standardized watershed assessments. For example, a watershed assessment in nearby Deer and Mill Creeks found that only 30 miles of roads contributed 50 percent of the sediment to these streams (Mike Kossow, Meadowbrook Conservation Assoc., Taylorsville, California, pers. comm.). Identification and rectification of similar problems in Battle Creek, through the watershed assessment process on public and private lands, would alleviate sediment transport problems which will eventually be translocated downstream to the anadromous fish habitat.

Concerns have been expressed by the BCWC that groundwater resources critical for populations of anadromous salmon and steelhead in the lower watershed may be affected by changes to meadows in the upper watershed (R. Lee, presentations to the BCWG, 1998). Meadows and other geological features in the watershed act to collect surface water and recharge groundwater aquifers. Because the unique salmon and steelhead habitat of the lower watershed is critically supported by large quantities of groundwater accretions, any negative impacts on the source of this groundwater should be seriously considered. In the meantime, meadows in the upper Battle Creek watershed should be protected to preserve an adequate source of groundwater in the lower watershed unless such protection is proven to be unnecessary.

CDFG (1996c) has recommended to “not plant resident trout in streams where identified populations of native coastal rainbow trout exist.” This recommendation was intended to minimize genetic mixing of native trout populations with introduced hatchery trout. Although there is not large-scale stocking in the lower watershed, and the small-

scale, private fish stocking there is not considered to be a major threat to anadromous fish because privately stocked fish are either sterile or stocked into canals where movement of live fish into Battle Creek is unlikely, the large-scale stocking of rainbow trout in the upper Battle Creek watershed should be closely evaluated in light of evidence demonstrating the deleterious effects of genetic mixing of hatchery and wild fish (NMFS 1997b), evidence of negative behavioral and ecological interactions between hatchery and wild fish (Berejikian 1995, 1996), and the interconnected relationship between resident rainbow trout and anadromous steelhead populations (e.g. Behnke 1992; Nielsen et al. 1997).

Privately-sponsored watershed restoration activities in the upper Battle Creek watershed need to be encouraged and monitored. Monitoring also needs to be performed in those streams where significant amounts of water are diverted to ensure that cumulative effects of multiple diversions and waste-water returns do not adversely affect water quality in the anadromous reaches of Battle Creek.

Battle Creek Anadromous Fish Habitat Upstream of CNFH

Introduction

The anadromous fish habitat upstream of CNFH is the primary focus for the restoration of salmon and steelhead because this area contains the primary spawning and rearing habitat for winter-run and spring-run chinook salmon, and steelhead. Furthermore, due to changes in concern for disease transmission to the CNFH (USFWS 1998f), this portion of the watershed will once-again function as significant spawning and rearing habitat for fall- and late-fall-run chinook salmon. Therefore, the majority of restoration planning efforts were directed at this portion of the watershed.

Several topics of concern in the anadromous portion of the watershed upstream of CNFH will be discussed individually in this section. These topics include flows, fish passage at dams, straying and false attraction of migrating salmon, natural barriers, water temperature, gravel management, and the control of disease transmission from wild chinook salmon populations to CNFH. For each of these topics, the existing conditions will be described, analysis of any existing or new data will be discussed, and specific restoration actions will be recommended where appropriate. However, negotiations between the resource agencies and PG&E are currently underway. Specific restoration actions will not be recommended in cases where these negotiations are likely to decide the course of restoration.

Preparation of this document, under the supervision of the BCWG, has been conducted simultaneously with the development of negotiations between resources agencies (e.g. USFWS, CDFG, NMFS, and USBR) and PG&E. Therefore, in those cases where PG&E facilities are concerned, this restoration document will merely identify restoration actions under consideration and will refer to a set of principles that the resource agencies have identified as essential for salmonid restoration and a necessary component of any negotiated settlement (Table 9).

Table 9. Biological principles that the USFWS, NMFS, CDFG, and USBR consider essential for salmonid restoration and a necessary component of any negotiated settlement with PG&E.

Biological Effectiveness – Restoration actions must incorporate the most biologically effective remedies that provide the highest certainty to successfully restore ecosystem functions and self-sustaining populations of native fish in a timely manner.

Restoring Natural Processes – Restoration actions must incorporate measures that mimic the hydrologic conditions under which Battle Creek anadromous fish resources evolved by increasing baseflows and eliminating mixing of North Fork and South Fork waters.

Biological Certainty – Restoration actions must provide maximum long-term effectiveness by minimizing long-term dependence on the integrity of man-made restoration actions and the cooperation of future project owners and operators.

Flows

Instream Flow

Existing FERC minimum flows within the anadromous portion of the watershed are 3 cfs at diversions in the North Fork and 5 cfs at diversions in the South Fork (U.S. Federal Power Commission 1973). An agreement between PG&E and USBR (USBR 1998a) specifies minimum flow releases of 30 cfs downstream of Eagle Canyon and Coleman dams and a cessation of diversions at Wildcat dam. However, the minimum flows set in USBR (1998a) are scheduled to expire in 2001, and absent a long-term agreement, minimum flows would presumably revert back to 3 cfs below all PG&E diversion in the North Fork and 5 cfs below all PG&E diversion in the South Fork consistent with PG&E's FERC license.

Biologically-optimum flows for anadromous fish within the area affected by the hydroelectric project were determined by the BCWG Biological Team, a subcommittee comprised of representatives from CDFG, NMFS, PG&E, and USFWS. The direction given to the Biological Team was to provide a single set of instream flow values, based on a determination of biologically-optimum flows for anadromous fishery restoration, that could be returned to the BCWG for use in restoration planning. The Biological Team met four times during 1998 on April 30, May 26, July 6, and August 17, and communicated steadily between meetings, including a final teleconference on August 31.

Two studies conducted by Thomas R. Payne and Associates (TRPA) in the late-1980s and early-1990s provided the foundation for Biological Team's decision-making process. The instream flow incremental methodology (IFIM) study performed by TRPA (1998a) described the relationship between instream flow and the quantity of fish habitat in each reach of the project-affected area for several fish species and lifestages. A fish migration barrier study (TRPA 1998b) identified flows necessary to insure adequate adult salmon migration at natural barriers.

Stream Reach Classification

The results of these two studies were interpreted with the aid of a classification system that anticipated the maximum potential restored fish habitat by reach and species. Each stream reach within the project-affected portion of the Battle Creek watershed was categorized by professional judgment using a system of five grades depending on a suite of attributes including potentially restorable temperature regime, cold water accretions from springs, physical habitat characteristics, species life history, length of stream reach, stream gradient, reach elevation, and past observations in similar watersheds (Table 10 and Table 11). Habitats of grades "A", "B", and "C" would have major contributions to the recovery of specified species while habitats of grades "D" and "E" would have a more modest contribution to salmonid restoration, especially in wet years. Habitats of grades "D" and "E" will contribute more to winter-run restoration in years when winter-run spawn early but may contribute little in years when winter-run spawn late in the season.

Water temperature data depicting existing conditions within the project-affected reaches of Battle Creek was collected during the summer and fall of 1995, 1996, and 1997 (raw data stored and graphed in KRIS-Battle). Temperature modeling results estimating water temperatures possible under a variety of restorable flow regimes were also examined for comparative purposes (TRPA 1998c and 1998d).

These temperature estimates for maximum potential restoration were compared to thermal criteria developed by Berman (1990; as cited in USFWS 1996b), Armour (1991), and USBR (1991) that specify levels at which warm water temperatures may negatively affect fish populations (Table 12). The focus of the temperature examination was on summer and fall months when high water temperatures were most likely to pose a risk to salmonids. For instance, the incubation of chinook salmon eggs to the eyed-egg stage, which takes 450 temperature units or roughly 2 weeks to complete after spawning at typical temperatures (USFWS 1982b), is considered particularly sensitive to water temperature (USBR 1991). The peak of the spawning period is mid-June for winter-run chinook and is September 15 for spring-run chinook. Therefore, anticipated restorable water temperature regimes from June 15 to June 30, and September 15 to September 30 were compared to egg incubation criteria (Table 12). Spring-run chinook adult-holding behavior occurs primarily from mid-March to the peak of spawning in mid-September (CDFG 1998b) so this time period was compared to criteria developed by USBR (1991; Table 12).

A paper by Cairns (1990) discussed frameworks for ecosystem restoration, suggested that ecosystem restoration should be based on restoring ecosystem function as closely as possible to original conditions, and should not be based on experimental systems subject to mechanical failures and uncertain biological responses. Of particular value is the use of reference streams with relatively undisturbed ecosystem functions relative to the ecosystem for which restoration planning is occurring. Following the Cairns (1990) approach, reference streams supporting populations of spring-run chinook in the upper Sacramento River, including Deer and Mill creeks, were examined to determine the temperature regime, elevation, and stream gradient that characterizes the reaches where adult spring-run chinook hold during their summer residence. Similarly, physical aspects of river systems that formerly contained spawning populations of winter-run chinook salmon, namely the McCloud and Little Sacramento rivers, were also examined. The physical attributes of these related ecosystems were then compared to Battle Creek in an attempt to determine how restored populations of spring- and winter-run chinook might utilize a restored Battle Creek.

In Deer and Mill creeks, spring-run chinook holding habitat is in high gradient stream segments with cooler temperatures at elevations ranging from 2,000 to 4,300 feet (Figure 5 through Figure 8). Reaches of similar gradient occur upstream of Eagle Canyon Dam in North Fork Battle Creek and upstream of Inskip Dam in the South Fork. Similar elevations of over 2,000 feet occur upstream of North Battle Creek Feeder Dam and upstream of the South Dam (Figure 9 and Figure 10).

Other criteria emerged upon consideration of Cairns' (1990) suggestions about ecosystem restoration. These were captured in a list of criteria for selecting the ecological characteristics and parameters for restoration actions within Battle Creek (Table 13).

Water temperature plays a strong role in determining the location of spring-run chinook holding habitat (CDFG 1998b). Suitable temperatures are optimum if less than 60.8°F and completely lethal greater than or equal to 80°F (Table 12). In July and August of 1992 and 1995, when water temperature data were available in Deer and Mill creeks, average summer water temperatures in these holding habitats were less than 66.5°F and were usually less than 62°F (Figure 5 through Figure 8). Predictions of water temperatures under a restored flow regime in Battle Creek using the SNTMP model (TRPA 1998c and 1998d) indicate a range of water temperatures between 60° and 70°F throughout the mainstem Battle Creek and the North Fork, and in the upper reaches of the South Fork. This estimated temperature regime, with varying degrees of suitability throughout Battle Creek, is much like that found in other streams supporting spring-run chinook (Figure 9 and Figure 10).

Water temperature also plays a strong role in determining the location and success of winter-run chinook spawning and egg incubation. Suitable temperatures are optimum if less than 58°F and completely lethal if greater than or equal to 62°F for a week or more (Table 12). Average June and July water temperatures in the McCloud River and Little Sacramento River, where winter-run chinook salmon used to spawn before construction of Shasta Dam, were less than 60°F and were usually less than 58°F in years with available, observed-temperature data (Figure 11 and Figure 12). Observed average water temperatures for June and July in 1995¹⁵, the only year with approximately complete temperature records, were less than 58°F in the entire North Fork and less than 60°F in the entire South Fork (Figure 13 and Figure 14). These temperature regimes would provide optimal spawning and incubation for winter-run in the North Fork and optimal to “low stress” conditions in the South Fork.

The classification system used to rank reaches of Battle Creek, which drew, in part, on these observations of water temperature and comparisons with other similar ecosystems, described the suitability of several reaches of Battle Creek for four species of anadromous salmonids (Table 14 and Table 15; Figure 15 through Figure 19). Under full restoration, habitat in North Battle Creek Feeder, Eagle Canyon, Wildcat, Panther, South, and Inskip reaches would provide major contributions to the production of winter- and spring-run chinook (Figure 15 and Figure 16). Habitat in Coleman, Mainstem, and Battle Creek Mouth reaches would provide modest contributions, especially in wet years, to the production of winter- and spring-run (Figure 15 and Figure 16). The production of fall- and late-fall-run chinook would be driven by restoration of habitat in the Wildcat,

¹⁵ Temperature conditions in 1995 may be different from temperature conditions in other years but 1995 data was used for the general purpose of comparing Battle Creek to historical winter-run habitat because 1995 was the only year with nearly-complete observed temperature records. The 1995 water year was above average for total discharge but instream flows in 1995 were less than anticipated flows under restored conditions. Air temperatures in 1995 were also higher than normal.

Coleman, Mainstem, and Battle Creek Mouth reaches and would derive modest contributions from habitat upstream of Wildcat and Coleman dams (Figure 17 and Figure 18). Habitat in all reaches of Battle Creek upstream of the confluence of the North and South forks would provide major contributions to the production of steelhead under full restoration (Figure 19). Habitat in the Mainstem and Battle Creek Mouth reaches would also provide modest contribution to steelhead production, under full restoration, especially in wet years. A total of 6.0 miles of streams tributary to Battle Creek, including the lowest ¼ mile of Digger Creek downstream from existing diversions, and Millseat, Bailey, Grapevine, Soap, Ripley, Baldwin, and Spring creeks, are suitable only for steelhead and,

all eggs produced by that female were deposited in the redd. Finally, several life-history characteristics were specified for chinook salmon based on published and unpublished information (Table 16).

Table 10. Description of restored habitat quality grades for spring-run chinook, winter-run chinook, and steelhead assuming maximum potential restoration.

Restored Habitat Quality Grade	Attribute
A	<ul style="list-style-type: none"> • High elevation and narrow canyon provides cool microclimate • Very large amount of cold water accretion from springs • Water temperature effects on sensitive life stages not measurable on an average year • Secluded adult holding habitat in pools greater than 3 feet deep • Adequate amount of habitat for spawning and juvenile rearing • Little or no competition with fall-run because high stream gradient and instream obstacles limit adult fall-run migration
B	<ul style="list-style-type: none"> • High elevation and/or narrow canyon provides cool microclimate • Moderate amount of cold water accretion from springs • Average year water temperature effects on sensitive life stages at or below threshold level of response • Secluded adult holding habitat in pools greater than 3 feet deep • Adequate amount of habitat for spawning and juvenile rearing • Little or no competition with fall-run because high stream gradient and instream obstacles limit adult fall-run migration
C	<ul style="list-style-type: none"> • Medium elevation with warm summer microclimate in canyon bottom • Limited amount of cold water accretion from springs • Open canyon provides limited topographic shading • Montane riparian shading present • Average year water temperature effects on sensitive life stage at level of chronic response • Secluded adult holding habitat in pools greater than 3 feet deep • Adequate amount of habitat for spawning and juvenile rearing • Stream gradient and instream obstacles partially limit migration of fall-run to reach • Limited competition with fall-run because stream gradient and instream obstacles partially limit adult fall-run migration • Low elevation with hot summer climate on stream bottom • No cooling influence provided by accretion from springs
D	<ul style="list-style-type: none"> • Low canyon walls provide little topographic shading • Much montane riparian shading • Average year water temperature effects on sensitive life stages at levels less than 50 percent survival • Partially accessible adult holding habitat with adequate amount of spawning habitat • Adequate pools for adult holding • Water temperature stratification in pools below cold water tributaries • Competition with partially sympatric fall-run
E	<ul style="list-style-type: none"> • Valley floor reach with hot summer climate • No cooling influence provided by accretions from springs • No topographic shading • Good shading from valley riparian community • Average year water temperature effects on sensitive life stages at less than 25 percent survival • Mostly accessible adult holding habitat • Limited pools for adult holding habitat and juvenile rearing • Adequate amount of spawning habitat • Full competition with sympatric fall-run including superimposition of redds

Table 11. Description of restored habitat quality grades for fall-run and late-fall-run chinook ¹⁶ assuming maximum potential restoration.

Restored Habitat Quality Grade	Attribute
A	<ul style="list-style-type: none"> • Low elevation and gradient with easy access for ripe fish • Located close to the Sacramento River • Wide channel with full flow of Battle Creek watershed • Alluvial stream reach with point bar formation • Adequate or abundant spawning gravel and fall water temperatures • No overlap with spring-run or winter-run chinook • Healthy valley riparian plant community
B	<ul style="list-style-type: none"> • Low elevation and moderate gradient with easy access for ripe fish • Located close to the Sacramento River • Wide channel with high flow • Entrenched meandering stream reach with point bar formation • Adequate spawning gravel and fall water temperatures • Little to no overlap with spring-run and winter-run chinook habitat • Healthy valley or montane riparian plant community
C	<ul style="list-style-type: none"> • Medium elevation and increasing gradient without migration obstacles • Increased distance from Sacramento River • Narrow channel in the forks of the stream with half of Battle Creek watershed flow • No meandering sections or point bars • Adequate spawning gravel and fall water temperatures • Overlap with spring-run chinook habitat that is judged fair to poor • Montane riparian plant community
D	<ul style="list-style-type: none"> • Medium elevation and high gradient without migration obstacles • Increased distance from Sacramento River • Narrow channel in the forks of the stream with half of Battle Creek watershed flow • No meandering or point bars but some broad riffles • Adequate spawning gravel and fall water temperatures • Overlaps with “good” winter-run and spring-run habitat • Montane riparian plant community
E	<ul style="list-style-type: none"> • Medium to high elevation with steep gradient and challenging migration barriers • Distant from Sacramento River • Narrow channel and lower flow • No meandering channel sections and limited spawning riffles • Adequate spawning gravel and fall water temperatures • Overlap with “superior” winter-run and spring-run habitat

¹⁶ Assumes that fall-run and late-fall-run will be allowed access above the CNFH barrier dam after the end of the spring-run spawning period on October 15th

Table 12. Thermal criteria used to evaluate summer water temperatures for suitability of winter-and spring-run chinook salmon. Criteria taken from Berman (1990; as cited in USFWS 1996b), Armour (1991), USBR (1991), and CDFG (1998b).

Timing, Species, Affected Life Stage	Mean Daily Water Temperature (°F)	Level of Response
June 15 to June 30 Winter-run chinook salmon Egg incubation to the eyed-egg stage	≤ 58 $>58, \leq 60$ $>60, \leq 62$ > 62	$<8\%$ mortality at 24 days 15 to 25% mortality at 20 days 50 to 80% mortality at 15 days 100% mortality at 7-12 days
July 1 to September 14 Spring-run chinook salmon Adult holding	≤ 60.8 $> 60.8, \leq 66.2$ > 66.2 ≥ 80	Optimum Some mortality and infertility No successful spawning Lethal
September 15 to September 30 Spring-run chinook salmon Egg incubation to the eyed-egg stage	≤ 58 $>58, \leq 60$ $>60, \leq 62$ > 62	$<8\%$ mortality at 24 days 15 to 25% mortality at 20 days 50 to 80% mortality at 15 days 100% mortality at 7-12 days

Table 13. Criteria developed by the BCWG Biological Team for selecting the ecological characteristics and parameters for restoration actions within Battle Creek.

Restoration Actions Within Battle Creek Must Meet the Following Criteria:
<ul style="list-style-type: none"> • Support ecological strategies developed by anadromous species by providing the environmental cues for upstream and downstream migration at the right times and to the right areas. • Be resistant to the catastrophic effects of drought by facilitating passage to the best stream environments during drought. • Provide stable environments not subject to drastic changes due to mechanical failures, inadequate maintenance, and reservoir drawdowns. • Support CNFH needs for redundant water supply systems during possible failure of water sterilization systems.

Table 14. Restored habitat quality grades in stream reaches of Battle Creek assuming maximum potential restoration. Detailed descriptions of restored habitat quality grades are in Table 10 and Table 11.

Stream	Reach Name	Length of Reach (miles)	Winter-run Chinook	Spring-run Chinook	Fall-run Chinook	Late-fall-run Chinook	Steelhead
North Fork	Keswick ¹⁷	4.13	D	D	E	E	C
North Fork	North Battle Creek Feeder	4.06	A	A	E	E	A
North Fork	Eagle Canyon	2.81	A	A	E	E	A
North Fork	Wildcat	2.48	C	B	C	C	A
South Fork	Panther	4.50 ¹⁸	B	A	E	E	A
South Fork	South	6.39	B	A	E	E	A
South Fork	Inskip	5.42	C	C	D	D	B
South Fork	Coleman	2.54	E	D	B	B	C
Mainstem	Mainstem	10.06	E	D	A	A	D
Mainstem	Battle Creek Mouth ¹⁹	5.09	E	E	B	B	D
Seven Tributaries ²⁰	Lower-Most Reaches	6.0	NA	NA	NA	NA	B - D

¹⁷ This table refers to the portion of the Keswick reach from the North Battle Creek Feeder Diversion upstream to a barrier falls locate 13.48 miles upstream from the confluence of the North and South forks of Battle Creek.

¹⁸ If a boulder falls at the Panther Creek Grade (about 2 miles upstream of South Diversion Dam) were modified to allow adult fish passage, then this reach would extend a total of about 4.5 miles upstream of the South Diversion Dam to approximately South Fork River Mile 18.85.

¹⁹ The Battle Creek Mouth reach extends from the upstream end of the backwater of the Sacramento River (about 1.9 miles upstream of the Battle Creek-Sacramento River confluence) upstream to the CNFH barrier dam.

²⁰ These tributaries to Battle Creek, which are suitable only for steelhead, include the lowest ¼ mile of Digger Creek downstream from existing diversions, and Millseat, Bailey, Grapevine, Soap, Ripley, Baldwin, and Spring creeks.

Figure 5. Average summer (July and August) water temperatures in the spring chinook holding reach of Deer Creek, 1992.

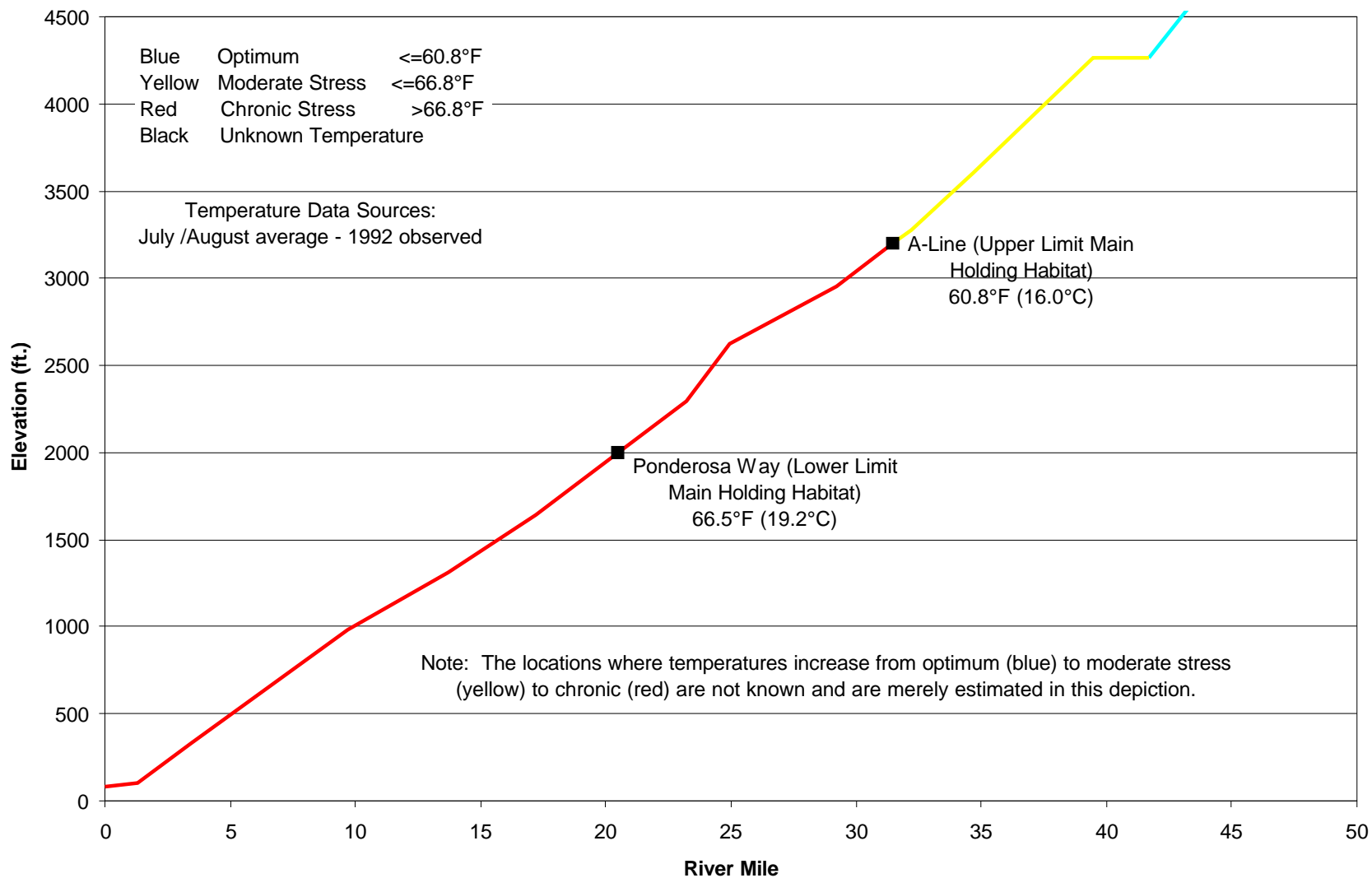


Figure 6. Average summer (July and August) water temperatures in the spring chinook holding reach of Deer Creek, 1995.

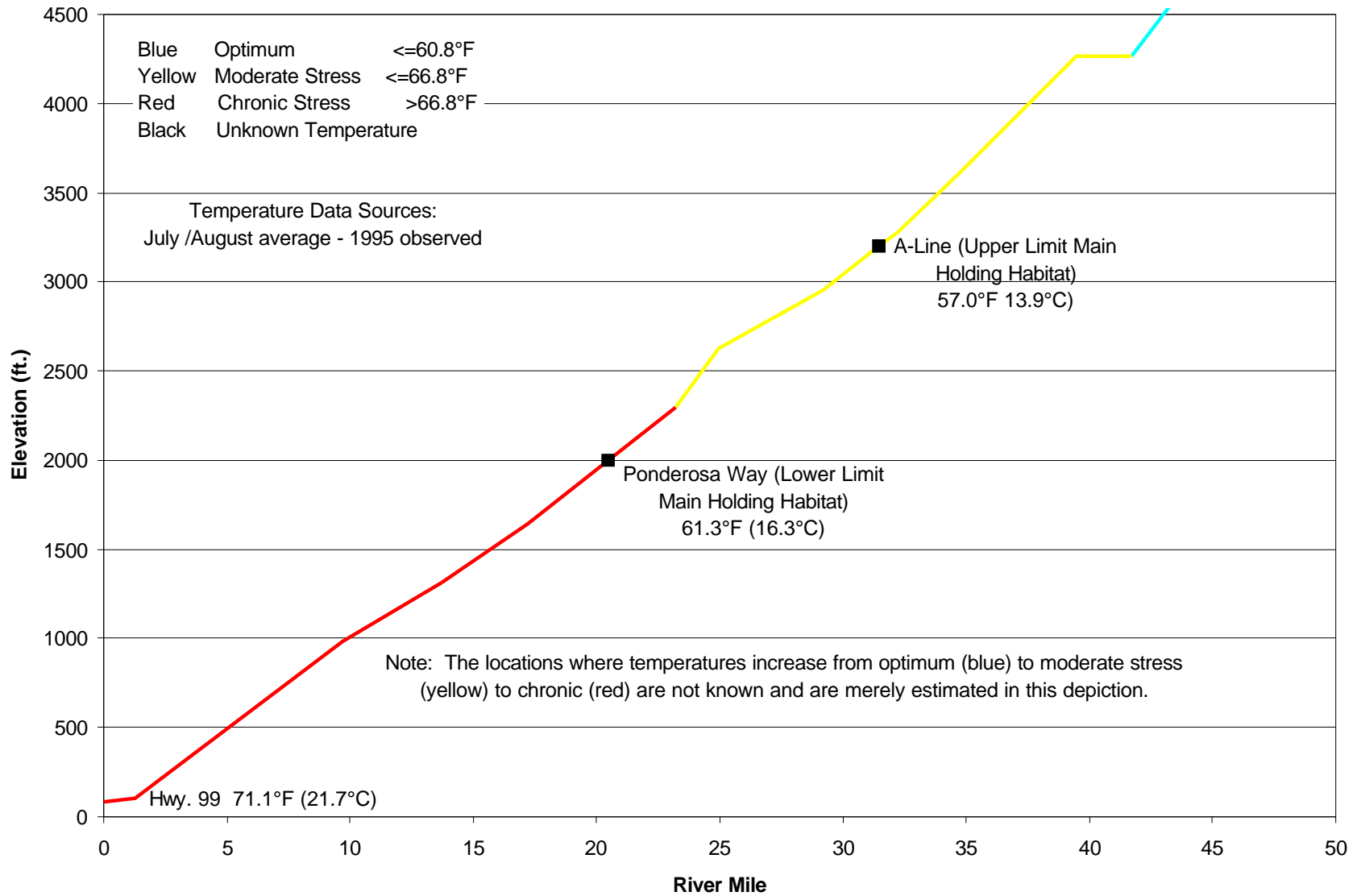


Figure 7. Average summer (July and August) water temperatures in the spring chinook holding reach of Mill Creek, 1992.

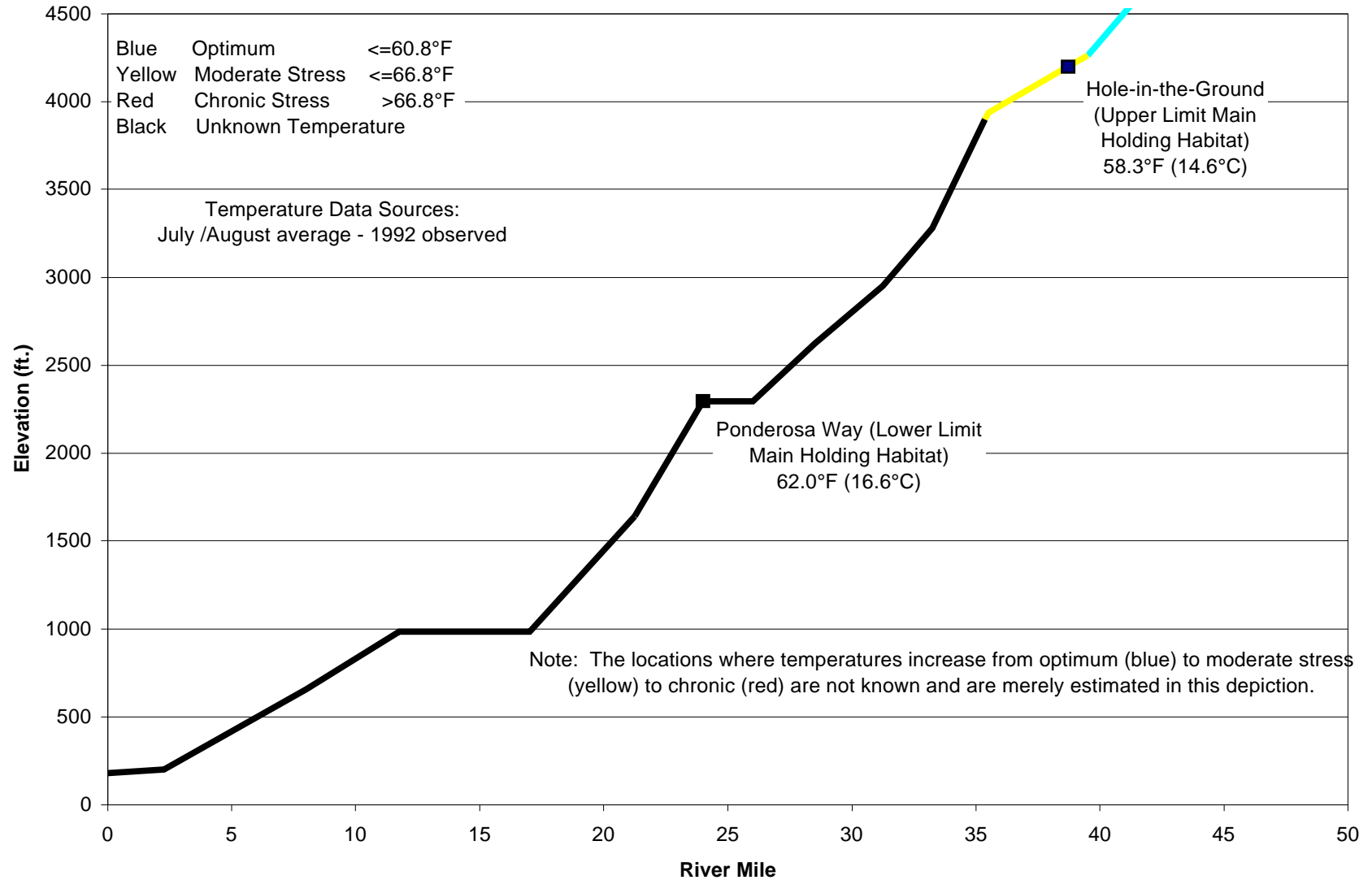


Figure 8. Average summer (July and August) water temperatures in the spring chinook holding reach of Mill Creek, 1995.

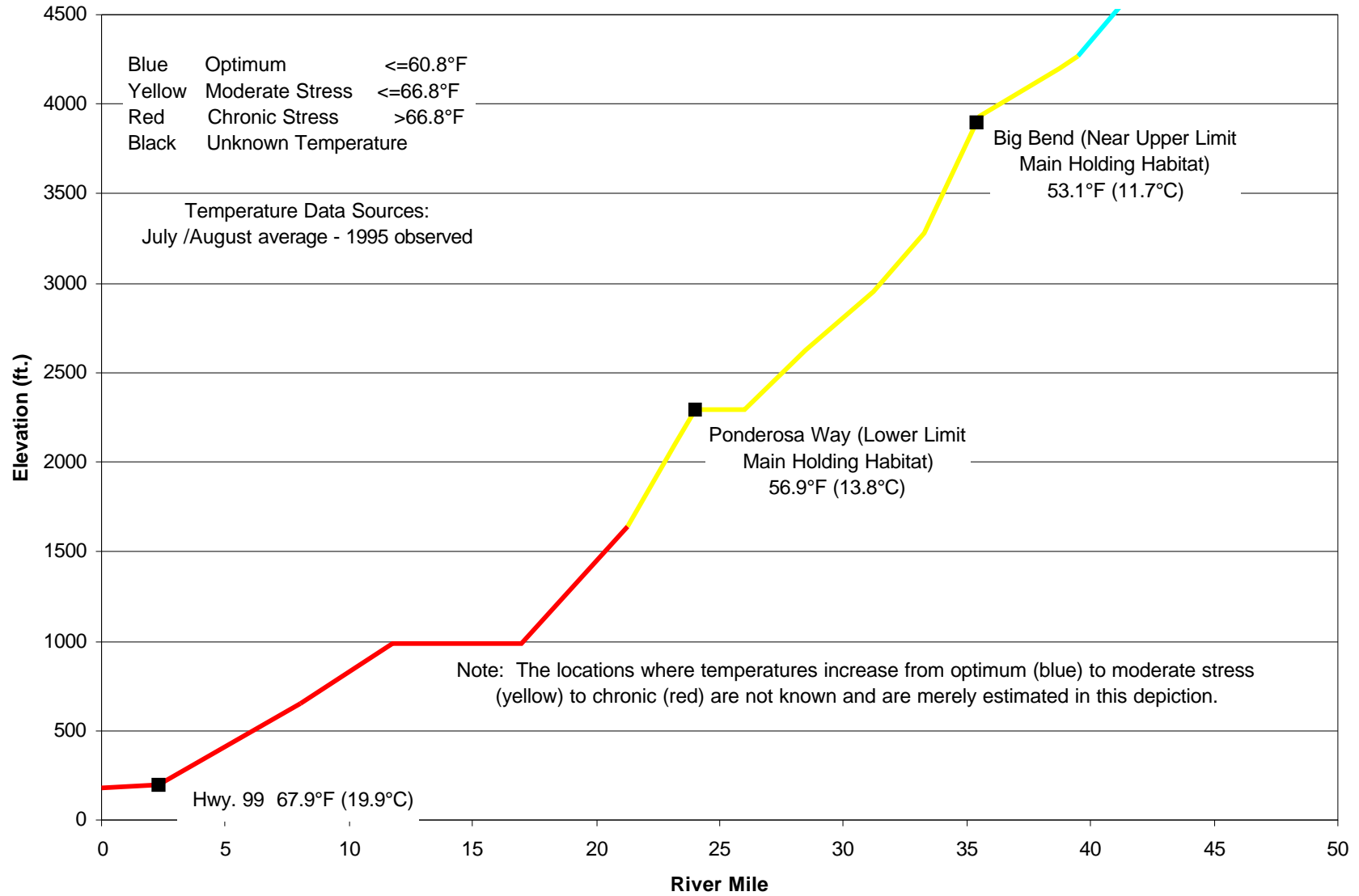


Figure 9. Average summer (July and August) water temperatures in the North Fork of Battle Creek, based on TRPA-SNTEMP and 1995 observed data.

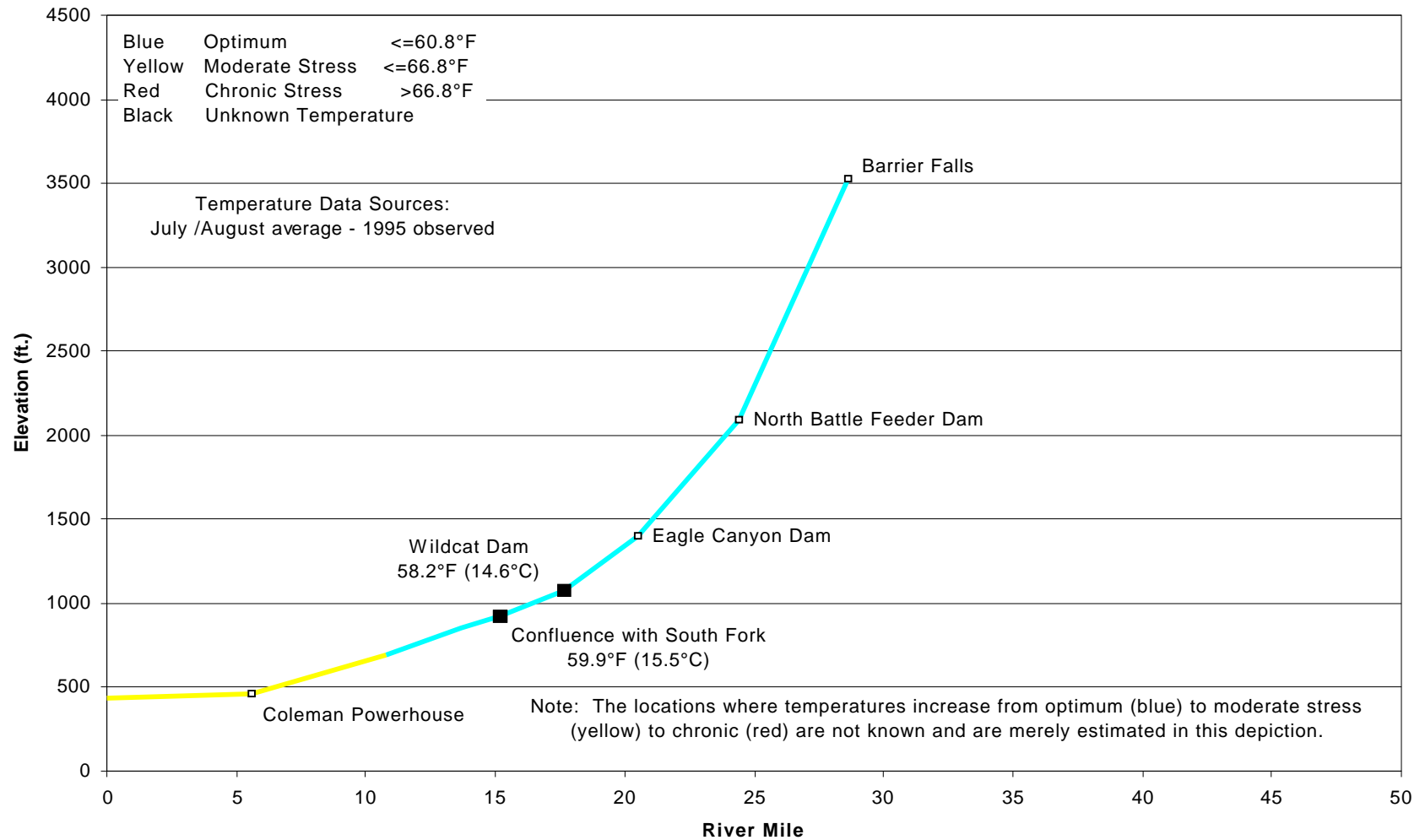


Figure 10. Average summer (July and August) water temperatures in the South Fork of Battle Creek, based on TRPA-SNTEMP output and 1996 observed data.

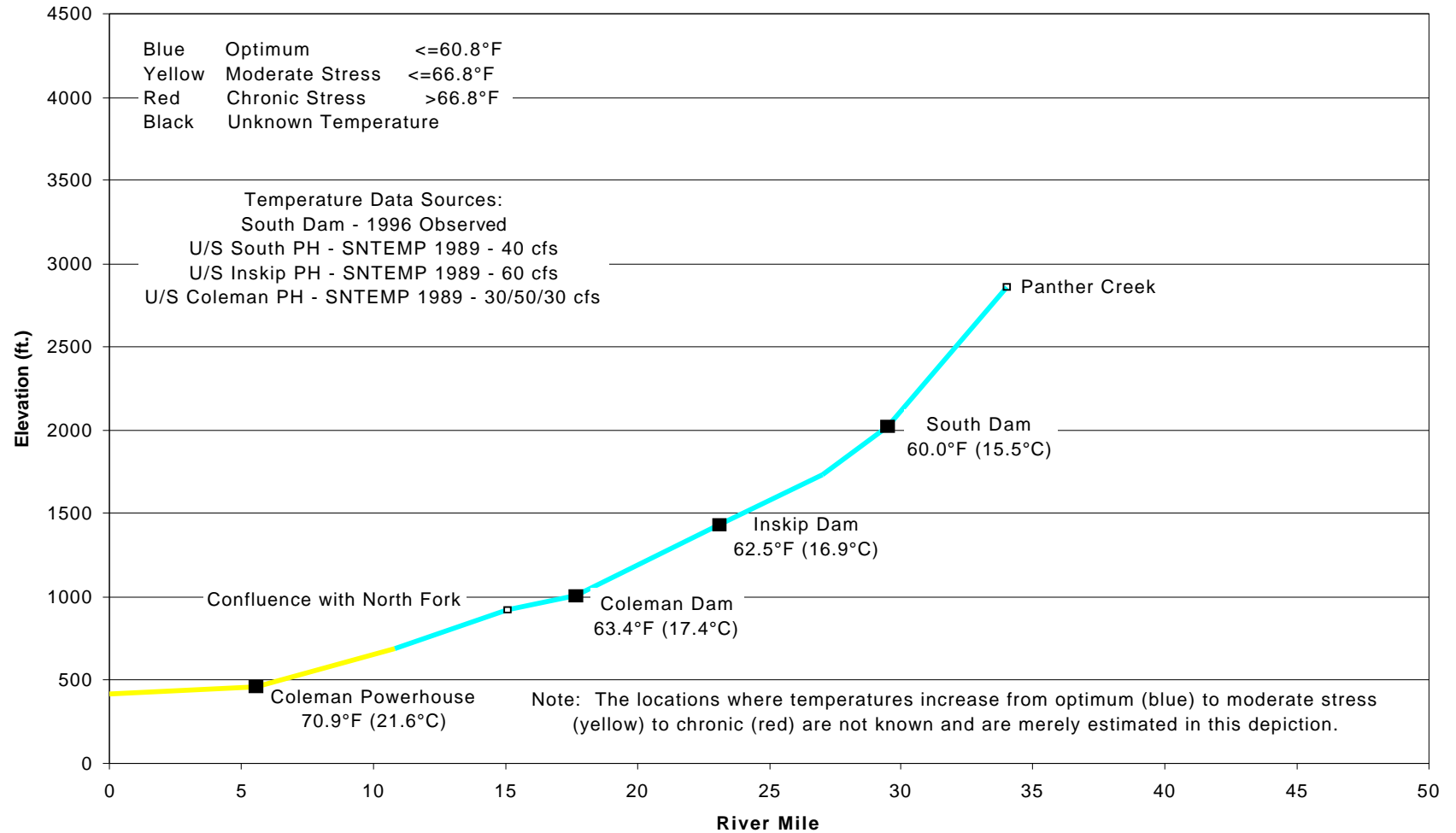


Figure 11. Average late spring (June and July) water temperatures in the former winter-run chinook salmon spawning habitat in McCloud River, 1963.

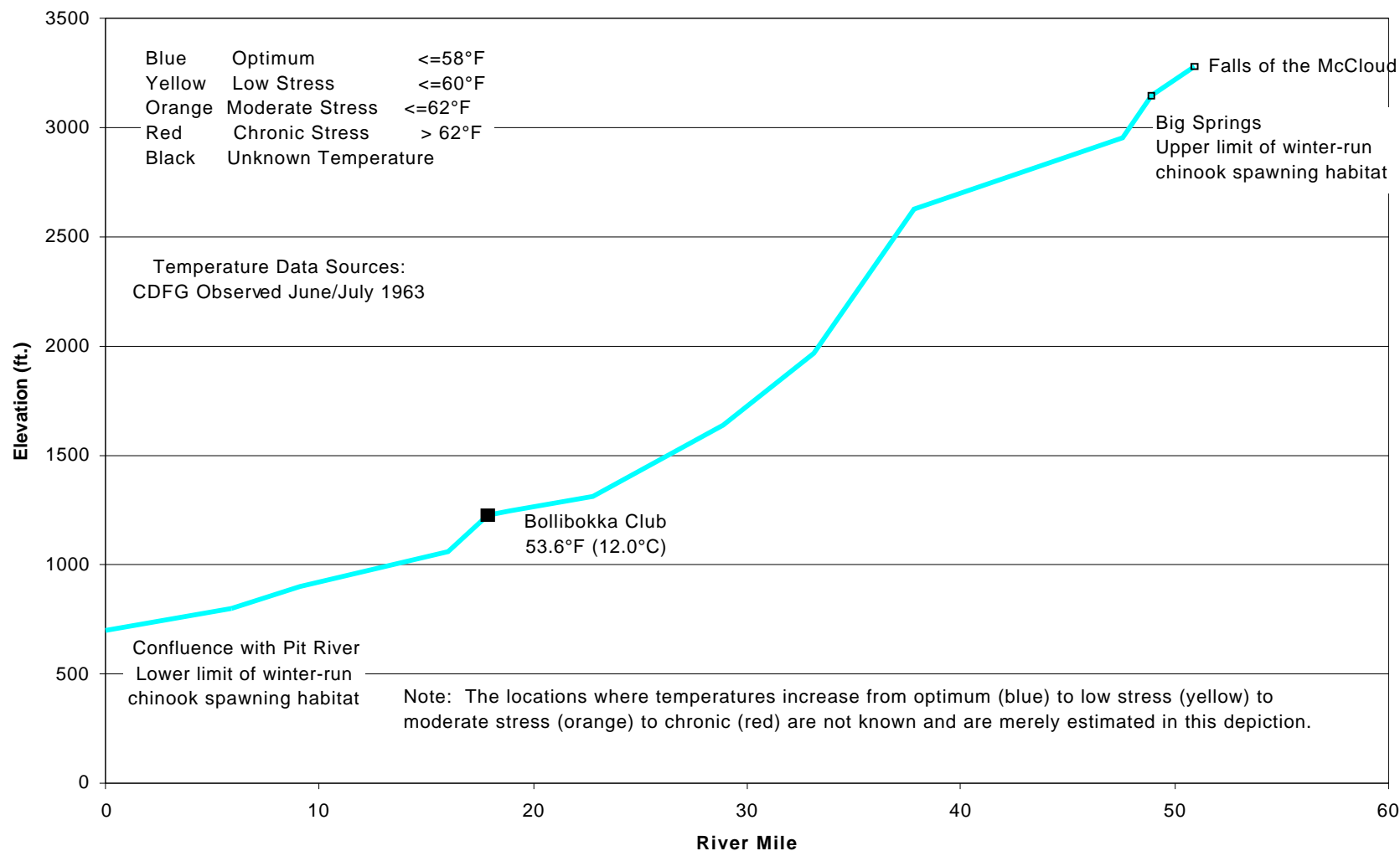


Figure 12. Average late spring (June and July) water temperatures in the former winter-run chinook salmon spawning habitat of the Little Sacramento River, 1978 and 1980.

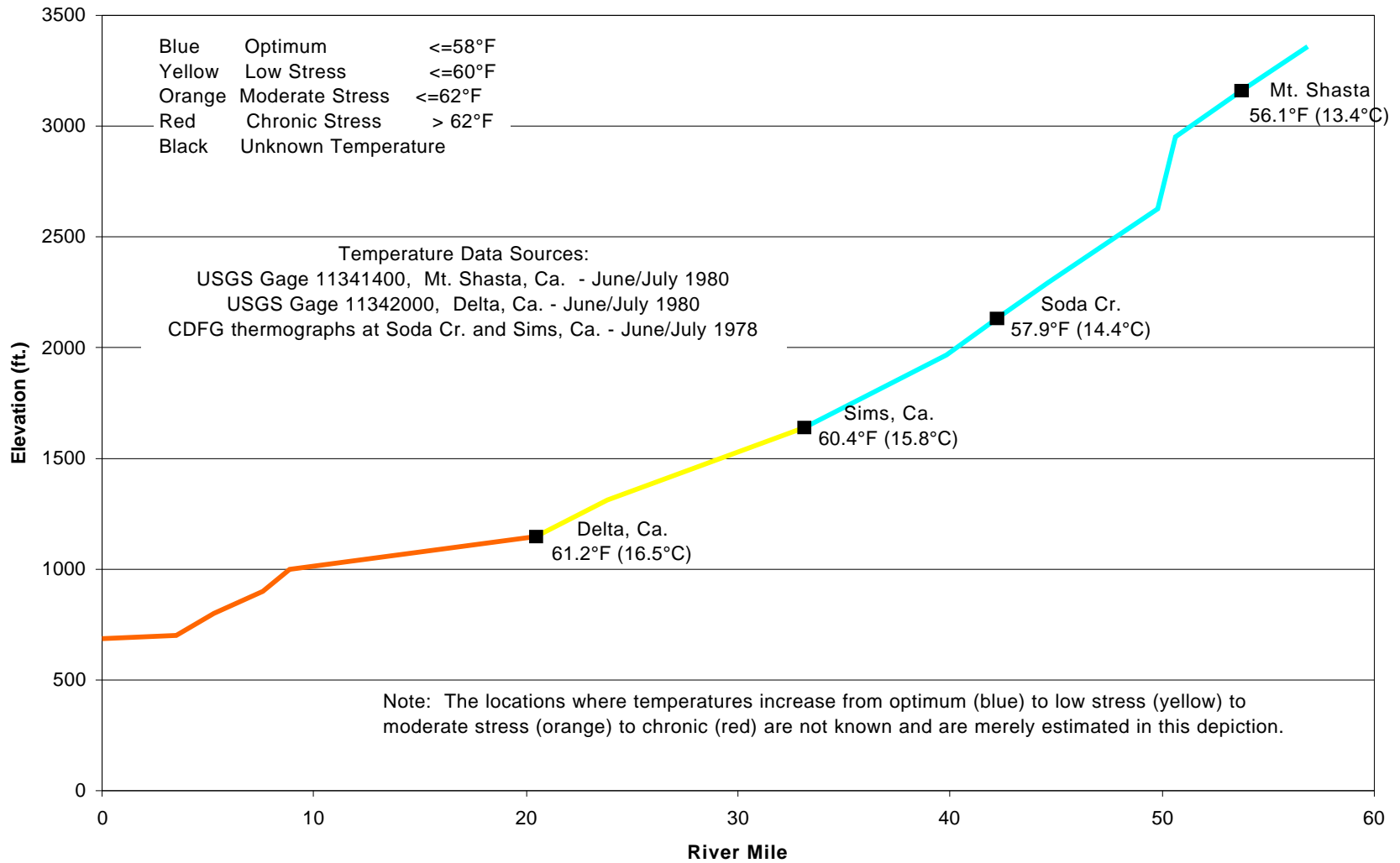


Figure 13. Average late spring (June and July) water temperatures in the winter-run chinook salmon spawning habitat of the North Fork of Battle Creek, 1995.

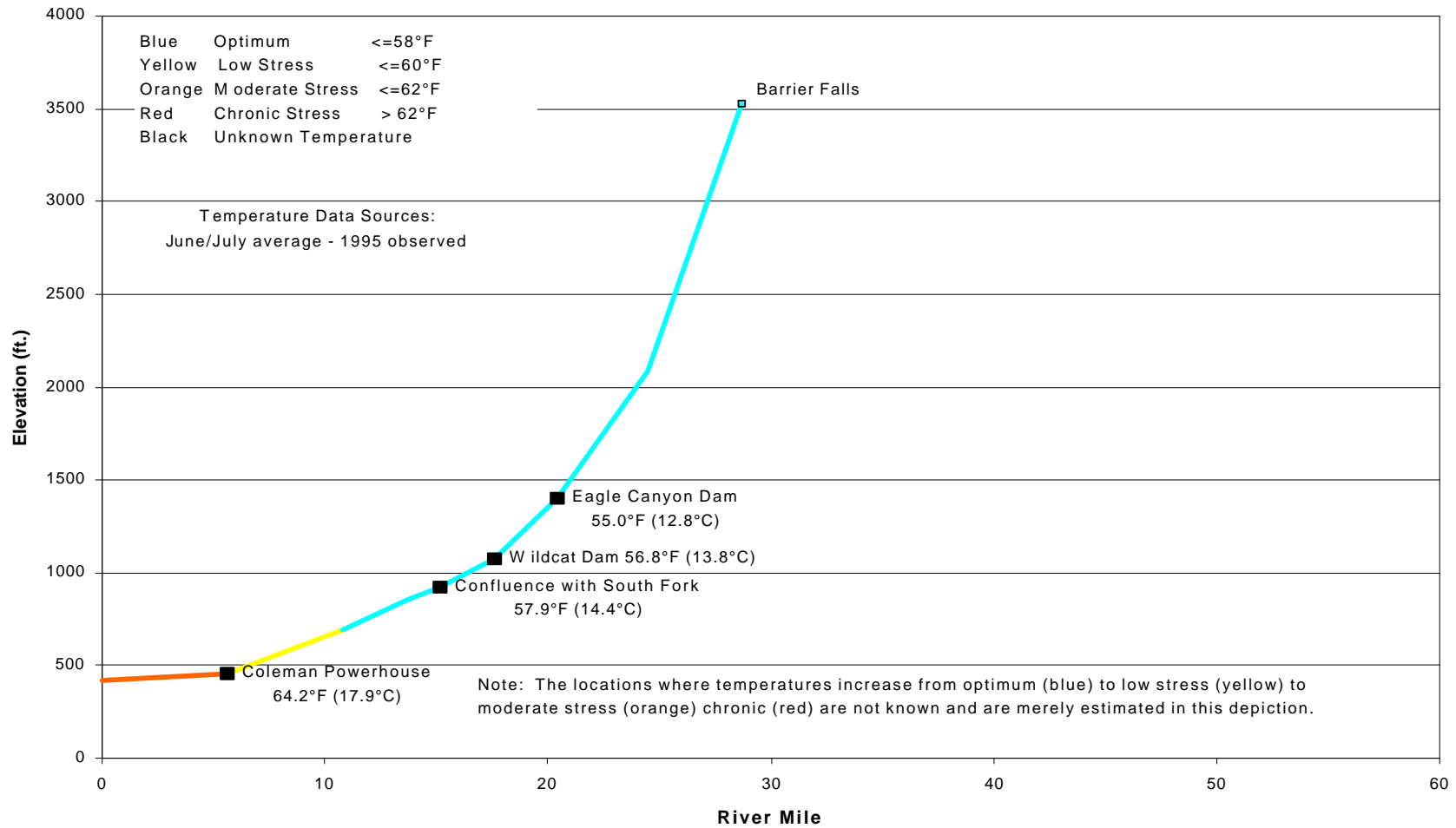


Figure 14. Average late spring (June and July) water temperatures in the winter-run chinook salmon spawning habitat of the South Fork of Battle Creek, 1995.

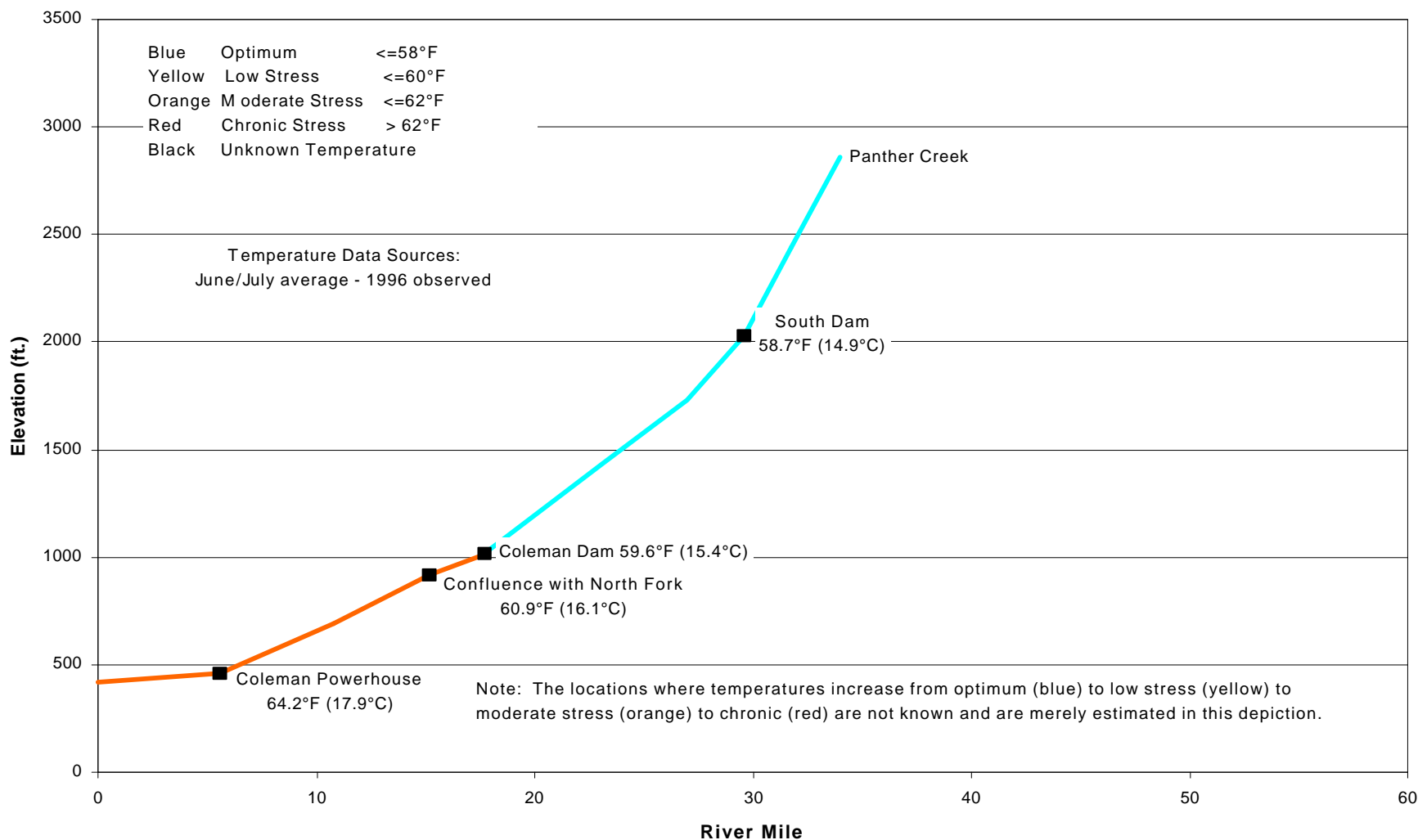
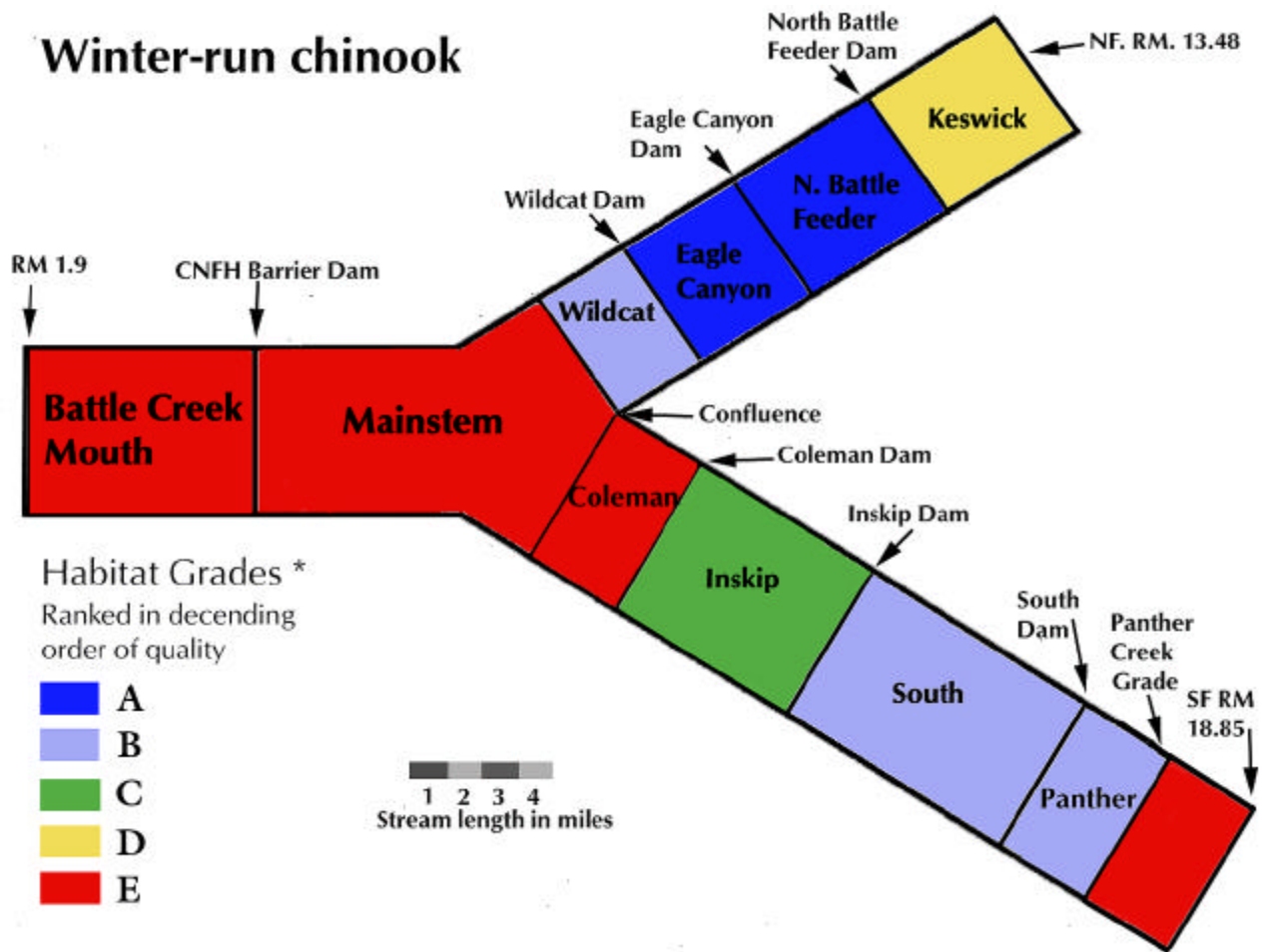


Figure 15. Anticipated maximum potential restored habitat for winter-run chinook salmon by stream reaches within the Battle Creek watershed.

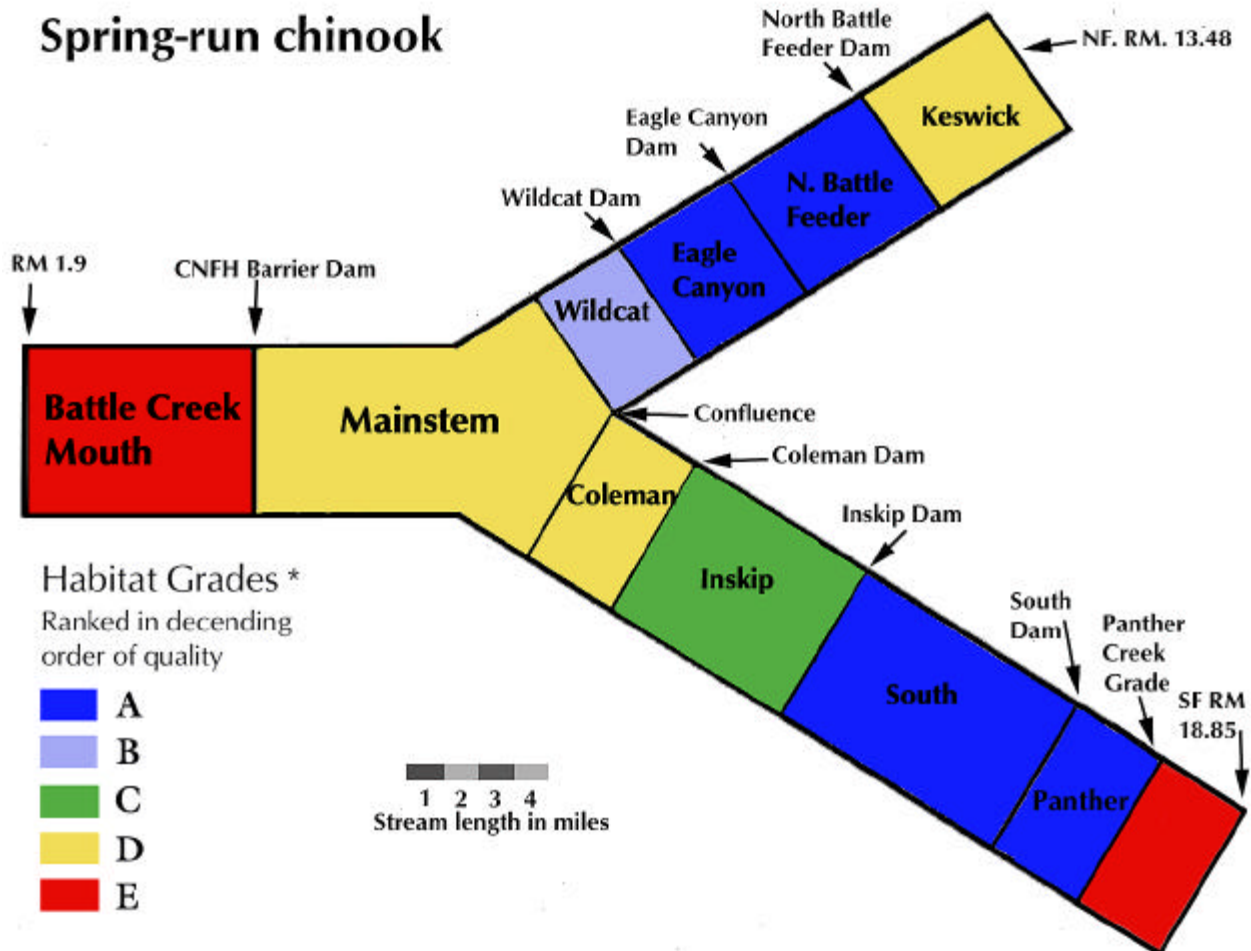


Habitat in the Wildcat reach would be reduced to "C grade" if instream flow releases were insufficient to maintain water temperatures for winter-run chinook incubation at levels that avoid chronic problems.

Habitat in the reach upstream of the Panther Reach would be improved to "B grade" if the boulder falls at the Panther Creek Grade were modified to allow anadromous fish passage.

*Habitat prioritization was determined by professional judgment based on restorable temperature regime, cold water accretions from springs, physical habitat characteristics, species life history, length of stream reach, stream gradient, and past observations in similar watersheds. For a more descriptive summary of habitat grades, see Table 10.

Figure 16. Anticipated maximum potential restored habitat for spring-run chinook salmon by stream reaches within the Battle Creek watershed.

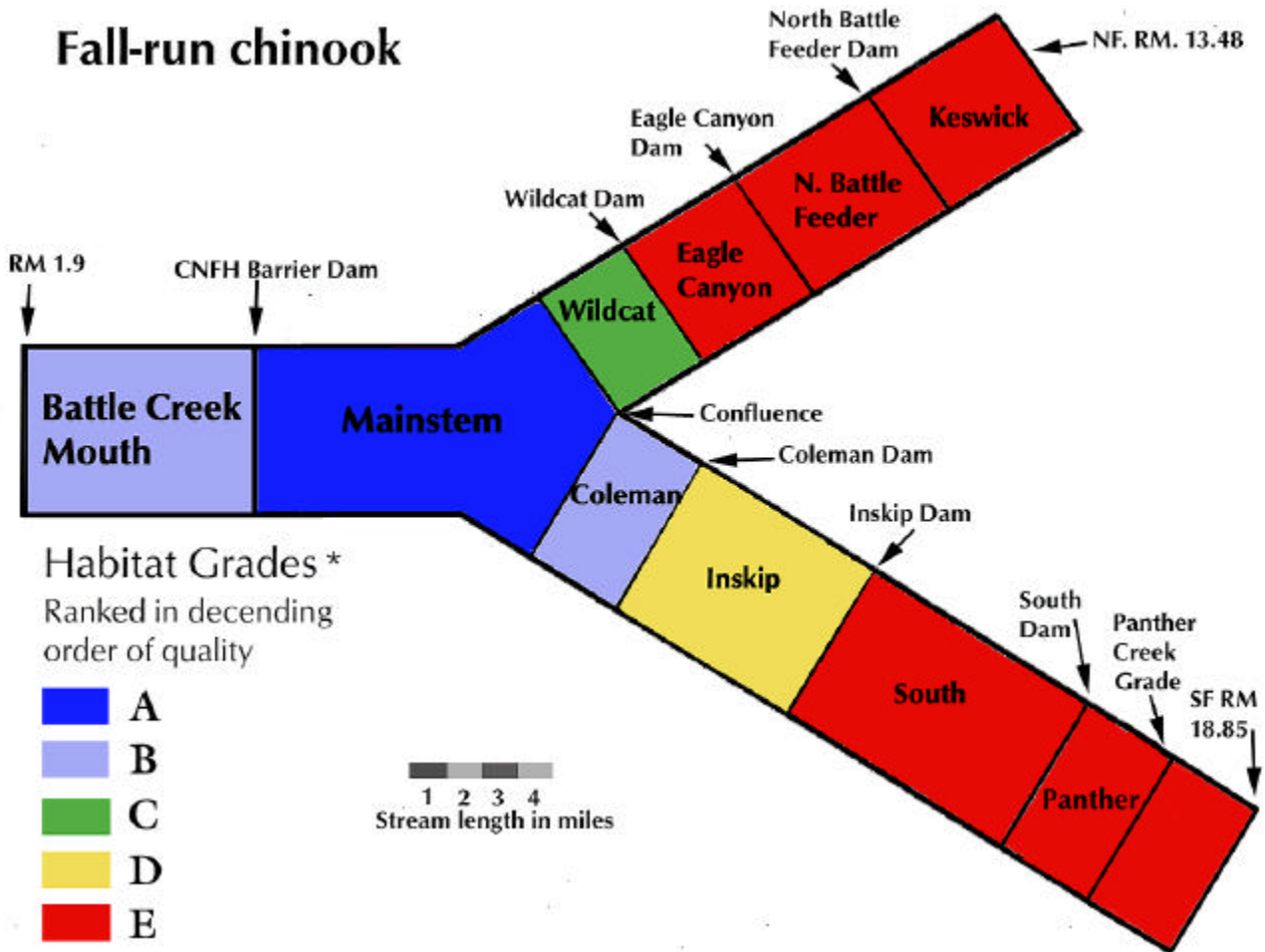


Habitat in the Wildcat reach would be reduced to "C grade" if instream flow releases were insufficient to maintain water temperatures for spring-run chinook incubation at levels that avoid chronic problems.

Habitat in the reach upstream of the Panther Reach would be improved to "A grade" if the boulder falls at the Panther Creek Grade were modified to allow anadromous fish passage.

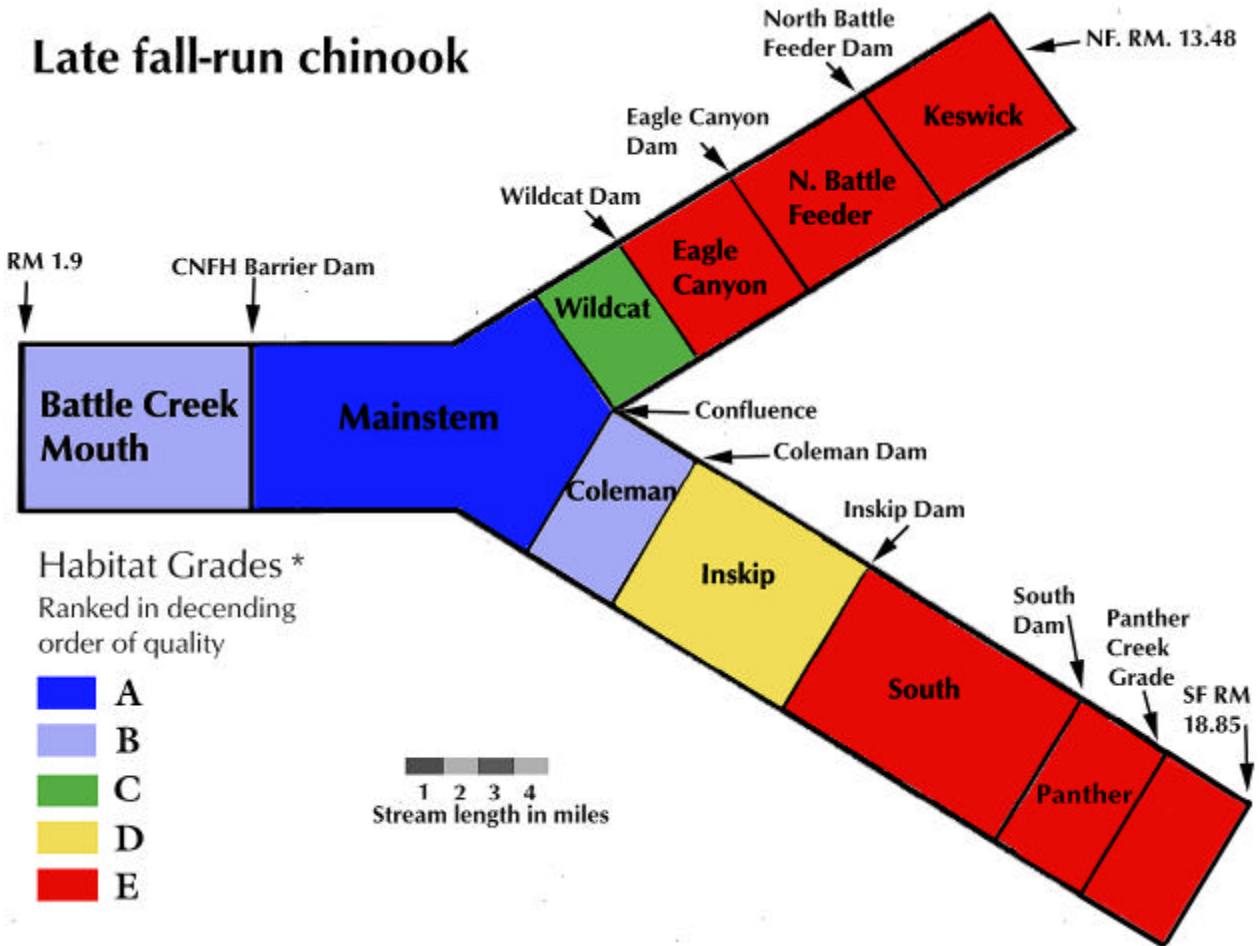
*Habitat prioritization was determined by professional judgment based on restorable temperature regime, cold water accretions from springs, physical habitat characteristics, species life history, length of stream reach, stream gradient, and past observations in similar watersheds. For a more descriptive summary of habitat grades, see Table 10.

Figure 17. Anticipated maximum potential restored habitat for fall-run chinook salmon by stream reaches within the Battle Creek watershed.



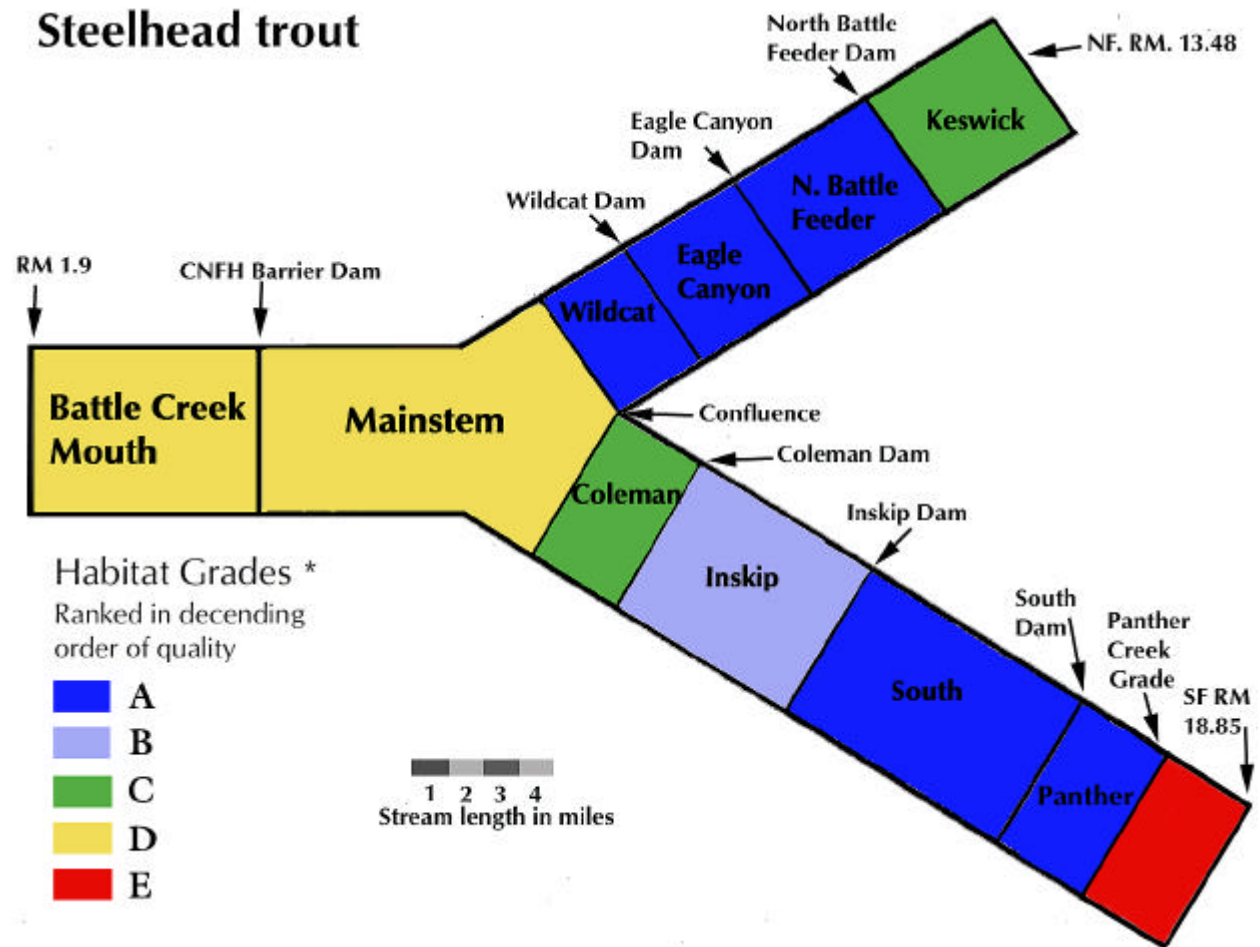
*Habitat prioritization was determined by professional judgment based on restorable temperature regime, cold water accretions from springs, physical habitat characteristics, species life history, length of stream reach, stream gradient, and past observations in similar watersheds. For a more descriptive summary of habitat grades, see Table 11.

Figure 18. Anticipated maximum potential restored habitat for late-fall-run chinook salmon by stream reaches within the Battle Creek watershed.



*Habitat prioritization was determined by professional judgment based on restorable temperature regime, cold water accretions from springs, physical habitat characteristics, species life history, length of stream reach, stream gradient, and past observations in similar watersheds. For a more descriptive summary of habitat grades, see Table 11.

Figure 19. Anticipated maximum potential restored habitat for steelhead by stream reaches within the Battle Creek watershed.



Habitat in the reach upstream of the Panther Creek Grade would be improved to "A grade" if the boulder falls at the Panther Creek Grade were modified to allow anadromous fish passage.

*Habitat prioritization was determined by professional judgment based on restorable temperature regime, cold water accretions from springs, physical habitat characteristics, species life history, length of stream reach, stream gradient, and past observations in similar watersheds. For a more descriptive summary of habitat grades, see Table 10.

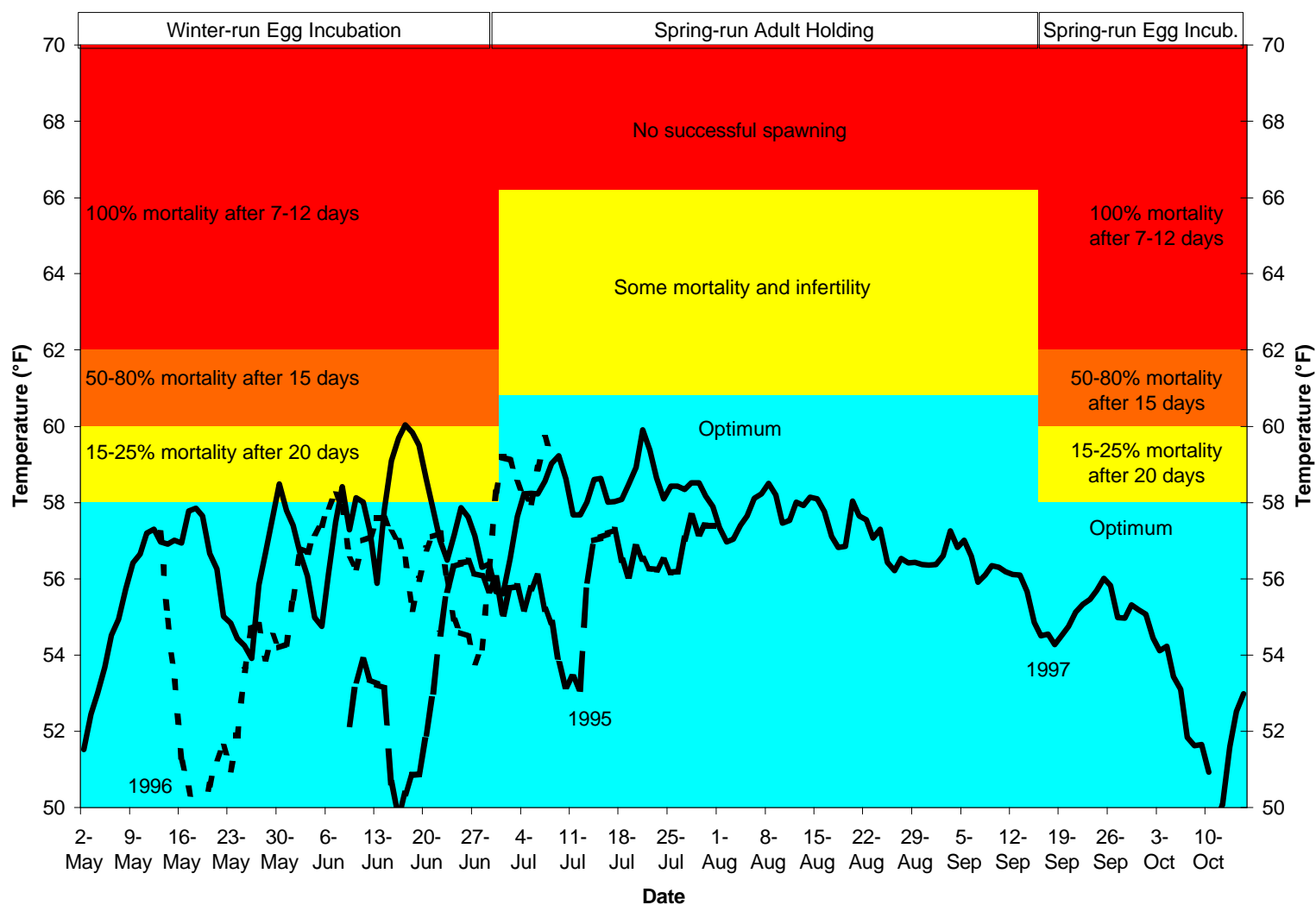


Figure 20. Daily average water temperature in the North Fork Battle Creek downstream of Eagle Canyon Dam compared to thermal criteria for critical life stages during three years of record

Table 16. Life-history characteristics of chinook salmon used in a model to predict which of three habitat types limited chinook production.

Life-history characteristic	Reference
Female spring-run chinook produce 3800 eggs	Scott Hamelberg, USFWS, Pers. Comm.
Female fall-run chinook produce 5000 eggs	Scott Hamelberg, USFWS, Pers. Comm.
Survival from spawning to fry is 25%	Hallock (1987)
Survival from spawning to juvenile is 15%	Hallock (1987)
43 fry are produced in each square meter of WUA	Mark Gard, USFWS, Pers. Comm. Bartholow et al. (unpubl.)
5.8 juveniles are produced in each square meter of WUA	Mark Gard, USFWS, Pers. Comm. Bartholow et al. (unpubl.)
The area of a chinook redd, including defense area, is 194 ft ²	Mark Gard, USFWS, Pers. Comm.

Table 17. An example application of the limiting life stage model used by the BCWG to interpret IFIM results.

South Reach Spring-Run or Winter-Run Chinook	
<ul style="list-style-type: none"> Flow of 50 cfs yields a carrying capacity of: <ul style="list-style-type: none"> Spawning: 936 ft² of WUA/1000' stream which provides habitat for 4.8 redds Fry: 2799 ft² of WUA/1000' stream which provides habitat for 11,195 fry Juvenile: 6161 ft² of WUA/1000' stream which provides habitat for 3,330 juvenile 4.8 successful redds can produce: <ul style="list-style-type: none"> 4.8 redds x 3800 eggs x 25% survival = 4,585 fry 4.8 redds x 3800 eggs x 15% survival = 2,751 juveniles 4,585 fry and 2,751 juveniles are less than the available carrying capacity. Therefore, spawning habitat for spring-run and winter-run chinook is limiting in the South reach. 	

Table 18. A list of chinook salmon life-history stages, determined to limit production by the limiting life stage model, in each reach of Battle Creek affected by the Battle Creek Hydroelectric Project.

North Fork and Mainstem		South Fork	
Reach	Life Stage	Reach	Life Stage
Keswick	Chinook were not a priority species in this reach	South	Winter-run chinook spawning Spring-run chinook spawning
North Battle Creek Feeder	Winter-run chinook spawning Spring-run chinook spawning	Inskip	Winter-run chinook rearing Spring-run chinook rearing
Eagle Canyon	Winter-run chinook rearing Spring-run chinook rearing	Coleman	Spring-chinook rearing Fall-run chinook rearing
Wildcat	Winter-run chinook spawning Spring-run chinook spawning Fall-run chinook spawning	Mainstem	Fall-run chinook spawning

Biologically-Optimum Flows

Results of the IFIM study, selected according to reach categorization, species prioritization, and limiting life stage, were used to make final flow determinations for incorporation into the set of biologically-optimum flows developed by the BCWG (Table 19 through Table 22). The use of the term "biologically-optimum" is not intended to imply that these flows are "perfect" or that they provide the maximum potential amount of habitat, as defined earlier in this "Technical Plan" section. Rather, the term identifies restored flows that are derived from the best available methodology for determining instream flows, minimize the take of habitat for listed species pursuant to Section 2081.0 of the California Fish and Game Code, and carefully balance overlapping ecological needs while recognizing the stated goal of maintaining stream-dependent economic values.

Biologically-optimum flows were determined for each reach and each month. These flows typically provided at least 95 percent of the maximum WUA²² for the priority species and limiting life-history stage present at that time. In some cases other considerations took precedence over adherence to the 95 percent of maximum WUA. These considerations included insuring adequate flows for adult salmon migration at natural barriers (based on a flow level of about 30 cfs specified in TRPA (1998b) as necessary to ascend most partial migration barriers in Battle Creek), balancing overlapping lifestages and species, preventing redd dewatering, considering the amount of inflow available at the upstream end of each reach, providing water to preserve the structural integrity of the South Canal, and assuming that accretions within the Keswick Reach upstream of the anadromous salmonid habitat would provide the necessary flows in the lower portion of this reach.

Preliminary flow values resulting from this process were compared with water temperature modeling results from the TRPA-SNTEMP model, water temperature observations made during the three-year interim flow agreement (USBR 1996), and results generated by an updated version of the TRPA-SNTEMP provided by PG&E. This examination was primarily intended to determine which reaches might be most sensitive to temperature effects caused by changes in instream flows. The reaches within the project-affected portion of Battle Creek that appear most sensitive to flow-related temperature changes were the Inskip and Wildcat reaches.

The final, biologically-optimum flows determined by this process are intended to describe the amount of water that would be released from the seven PG&E dams affecting the portions of Battle Creek inhabited by anadromous salmonids should this flow regime be adopted in final negotiations (Table 23). Restoration flows were also determined for springs and streams tributary to the North and South forks of Battle Creek that were identified to have significant value to the restoration of anadromous salmonids in Battle

²² Pursuant to Section 2081.0 of the California Fish and Game Code, the taking of species, listed under the California Endangered Species Act, or their habitat, should be "minimized or fully mitigated." In this case, releasing flows which provided 95 percent of maximum WUA was considered to "minimize" the take of habitat for listed species.

Creek (Table 24). Eagle Canyon Springs, previously diverted by PG&E into the Eagle Canyon Canal, would be continue to be released to the North Fork immediately downstream of Eagle Canyon Dam in the manner established in the interim flow agreements between PG&E and the USBR in order to provide fish habitat as well as to provide cooling effects (USBR 1998). A survey of Soap Creek by CDFG in 1998 indicated that this stream contains approximately one mile of habitat suitable for the spawning and early rearing of steelhead during the wet season. Soap Creek also functions to provide cool water to the South Fork in summer. For these reasons, all flow in Soap Creek would be released as instream flow from June through October and 10 cfs will be release during the rest of the year. Ripley Creek also contains one mile of habitat for steelhead spawning but has been shown by the SNTMP model to provide warm water to the South Fork in summer. For these reasons, the lower diversion on Ripley Creek, operated by PG&E, would release 3 cfs during the steelhead spawning and egg incubation periods and will be operated according to existing practices during the summer. Restoration actions in Baldwin Creek would include periodic gravel enhancement downstream of PG&E's Asbury Pump diversion, barrier modification, and an instream flow release of 5 cfs pending a survey of Baldwin Creek by the BCWG during the fall of 1998.

For purposes of economic analysis, final biologically-optimum flows were compared to estimates of inflow to each diversion dam (Table 25). Two independent estimates of inflow were developed by Resource Management Incorporated (RMI 1998) and PG&E. The RMI estimates were derived using upstream drainage areas to apportion the total Battle Creek flow recorded at the USGS stream gage below CNFH in 1989. The PG&E data entered in the table were derived from both recorded and interpolated gage information at each diversion site for 1989.

The Biological Team made a series of logical choices to select water year 1989 as representative of typical conditions in Battle Creek. These choices were made with the intent of determining a "typical" year for energy production and do not represent standard methodology for determining hydrologically "normal" water years. First, water years 1981 through 1993 were selected from the period of record because PG&E facilities were not completely upgraded in years before 1981 and because FERC minimum flows were augmented by the interim flow agreement (USBR 1996) in years after 1993. Second, daily average flows were calculated for each of the 13 years and were ranked. The daily average flow for water year 1989 was the median of these ranked values and, therefore, 1989 was selected as the "typical" water year. Though the shape of the yearly hydrographs for each of three years bracketing the median value (i.e. water years 1985, 1989, 1993) were substantially different from one another, the selection of 1989 as "typical" was supported by the fact that 1989 was also the median of these three years in terms of energy production.

Current negotiations between PG&E and the resource agencies are expected to result in recommended minimum instream flow levels which should meet the principles outlined in Table 9.

Table 19. Flows providing maximum WUA for limiting life stages and biologically-optimum ecosystem restoration flows in the upper two reaches of North Fork Battle Creek, California.

Reach	Priority Species	Monthly Minimum Flow (cfs) Released From Dam											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Keswick	Steelhead spawning	46	46	46	46								46
	Steelhead rearing	31	31	31	31	31	31	31	31	31	31	31	31
	Optimum	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A
N. Battle Creek Feeder	Winter chinook spawning				60	60	60	60	60				
	Spring chinook spawning								60	60	60		
	Steelhead spawning	120	120	120	120								120
	Optimum	88 ^{95,F}	88 ^{95,F}	88 ^{95,F}	67 ^{B0,F}	47 ^{95,F}	47 ^{95,F}	47 ^{95,F}	47 ^{95,F}	47 ^{95,F}	47 ^{95,F}	47 ^{95,F,I}	88 ^{95,F}

Shaded cells denote focus lifestage.

95 = Ninety-five percent of maximum WUA for focus life stage.

A = Accretion flows downstream of the Keswick Dam can exceed 100% of maximum WUA for steelhead spawning in the portion of the Keswick reach available to anadromous fish and can exceed the predictive capability of the IFIM model. Accretion flows downstream of the Keswick Dam provide >90% of maximum WUA for steelhead rearing in the portion of the Keswick reach available to anadromous fish (Table 25).

F = On occasion the release is not attainable due to the quantity of inflow reaching North Battle Creek Feeder Diversion. Additional inflows to the North Battle Creek Feeder Reach are occasionally received from the junction box of the Volta 2 Powerhouse tailrace and Cross-Country Canal a short distance downstream.

B0 = Balance steelhead spawning with chinook spawning = The stepped downramp from 88 to 47 cfs will avoid a 27 percent loss of steelhead habitat.

Table 20. Flows providing maximum WUA for limiting life stages and biologically-optimum ecosystem restoration flows in the lower two reaches of North Fork Battle Creek, California.

Reach	Priority Species	Monthly Minimum Flow (cfs) Released From Dam											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Eagle Canyon	Winter chinook rearing	40	40	40				40	40	40	40	40	40
	Spring chinook rearing	40	40	40	40	40						40	40
	Steelhead spawning	60	60	60	60								60
	Optimum	46 ^{95,S,B1}	46 ^{95,S,B1}	46 ^{95,S,B1}	46 ^{95,S,B1}	35 ^{S,M1}	35 ^{S,M1}	35 ^{S,M1}	35 ^{S,M1}	35 ^{S,M1}	35 ^{S,M1}	35 ^{S,M1}	46 ^{95,S,B1}
Wildcat	Winter chinook spawning				25	25	25	25					
	Spring chinook spawning								25	25	25		

Table 21. Flows providing maximum WUA for limiting life stages and biologically-optimum ecosystem restoration flows in the upper two reaches of South Fork Battle Creek, California.

Reach	Priority Species	Monthly Minimum Flow (cfs) Released From Dam											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
South	Winter chinook spawning				65	65	65	65	65				
	Spring chinook spawning								65	65	65		
	Steelhead spawning	105	105	105	105								105
	Optimum	73 ^{90,N1}	73 ^{90,N1}	73 ^{90,N1}	54 ^{95,N1}	54 ^{95,N1}	54 ^{95,N1}	54 ^{95,N1}	54 ^{95,N1}	54 ^{95,N1}	54 ^{95,N1}	54 ^{95,N1}	54 ^{I,N1}
Inskip	Winter chinook rearing	55	55	55	55			55	55	55	55	55	55
	Spring chinook rearing	55	55	55	55	55			55	55	55	55	55
	Steelhead spawning	120	120	120	120								120
	Optimum	86 ^{B2}	86 ^{B2}	86 ^{B2}	61 ^{B3}	40 ^{95,P1}	40 ^{95,P1}	40 ^{95,P1}	40 ^{95,P1}	40 ^{95,P1}	40 ^{95,P1}	40 ^{95,P1}	40 ^{95,P1}

Shaded cells denote focus lifestage.

95 = Ninety-five percent of maximum WUA for focus life stage.

90 = Ninety percent of maximum WUA to accommodate natural hydrograph and diminish the flow drop to winter-run spawning and incubation flows.

N1 = The prescribed instream flow will be the natural flow arriving at the South Dam, minus 5 cfs, at times when the natural inflow is less than the optimum flow plus 5 cfs. A release of 5 cfs will be maintained in the South Canal at all times to preserve the physical integrity of the South Canal.

I = Spawning flows sustained to prevent redd dewatering.

P1 = The prescribed instream flow will be the total available inflow from the South Fork upstream of the South Powerhouse at times when the available inflow is less than the optimum flow.

B2 = Balance steelhead spawning with chinook rearing – 86 cfs released at Inskip Dam provides 90% of maximum WUA for both focus species/lifestages.

B3 = Balance steelhead spawning, chinook rearing, and winter-run chinook spawning and incubation – 61 cfs released at Inskip Dam provides ≥ 95% of maximum WUA for all focus species/lifestages.

Table 22. Flows providing maximum WUA for limiting life stages and biologically-optimum ecosystem restoration flows in the lowest reach of the South Fork and in the mainstem of Battle Creek, California.

Reach	Priority Species	Monthly Minimum Flow (cfs) Released From Dam											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Coleman	Steelhead rearing	45	45	45	45	45	45	45	45	45	45	45	45
	Spring chinook spawning									55	55		
	Fall chinook rearing	55	55	55	55	55	55						55
	Steelhead spawning	120	120	120	120								120
	Optimum	92 ^{B4,P2}	92 ^{B4,P2}	92 ^{B4,P2}	92 ^{B4,P2}	77 ^{B5,P2}	42 ^{B6,P2}	29 ^{95,P2}	29 ^{95,P2}	38 ^{95,P2}	38 ^{95,P2}	38 ^{95,P2}	92 ^{B4,P2}
Mainstem	Steelhead spawning	136	136	136	136								136
	Steelhead rearing	76	76	76	76	76	76	76	76	76	76	76	76
	Fall chinook spawning										86	86	86
	Inflow - Sum of Forks	141 ^X	141 ^X	141 ^X	127 ^X	107 ^X	72 ^X	59 ^X	59 ^X	68 ^X	68 ^X	68 ^X	141 ^X
	Optimum	112 ⁹⁵	112 ⁹⁵	112 ⁹⁵	112 ⁹⁵	112 ⁹⁵	45 ⁹⁵	45 ⁹⁵	45 ⁹⁵	45 ⁹⁵	60 ⁹⁵	60 ⁹⁵	112 ⁹⁵

Shaded cells denote focus lifestage.

95 = Ninety-five percent of maximum WUA for focus life stage.

B4 = Balance steelhead spawning with chinook rearing - 92 cfs provides about 90% of maximum WUA for both lifestages.

B5 = Balance steelhead and fall chinook rearing with biological optimum in Mainstem Reach - 77 cfs, in addition to a 35 cfs release from Wildcat Dam, provides optimum flow for the Mainstem Reach and provides for ≥ 95% of maximum WUA for fall chinook rearing and ≥ 90% of maximum WUA for steelhead rearing in the Coleman Reach.

B6 = Balance chinook rearing, steelhead rearing and provides adequate flows for adult salmon migration at natural barriers – 42 cfs provides > 99% of maximum WUA for steelhead rearing, 95% of maximum WUA for fall chinook rearing, and 95% of maximum WUA for rearing winter- or spring-run chinook displaced from upstream spawning sites.

X = The sum of optimum flows from the North and South forks listed here provides ≥ 95% of maximum WUA all focus species/lifestages.

I = Spawning flows sustained to prevent redd dewatering.

P2 = The prescribed instream flow will be the total available inflow in the South Fork upstream of the Inskip Powerhouse at times when the available inflow is less than the optimum flow.

Table 23. Summary of prescribed instream flow releases from dams in the anadromous reaches of the North and South forks of Battle Creek based on biological optimums determined by the BCWG.

Dam	Fork	Monthly Minimum Flow (cfs) To Be Released From Dam											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Keswick	North	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A	3 ^A
NBCF	North	88 ^F	88 ^F	88 ^F	67 ^F	47 ^F	47 ^F	47 ^F	47 ^F	47 ^F	47 ^F	47 ^F	88 ^F
Eagle	North	46 ^S	46 ^S	46 ^S	46 ^S	35 ^S	35 ^S	35 ^S	35 ^S	35 ^S	35 ^S	35 ^S	46 ^S
Wildcat	North	49	49	49	35	30	30	30	30	30	30	30	49
South	South	73 ^{N1}	73 ^{N1}	73 ^{N1}	54 ^{N1}	54 ^{N1}	54 ^{N1}	54 ^{N1}	54 ^{N1}	54 ^{N1}	54 ^{N1}	54 ^{N1}	73 ^{N1}
Inskip	South	86 ^{P1}	86 ^{P1}	86 ^{P1}	61 ^{P1}	40 ^{P1}	40 ^{P1}	40 ^{P1}	40 ^{P1}	40 ^{P1}	40 ^{P1}	40 ^{P1}	86 ^{P1}
Coleman	South	92 ^{P2}	92 ^{P2}	92 ^{P2}	92 ^{P2}	77 ^{P2}	42 ^{P2}	29 ^{P2}	29 ^{P2}	38 ^{P2}	38 ^{P2}	38 ^{P2}	92 ^{P2}

Technical rationales for how each flow was derived are provided in the footnotes to Table 19 through Table 20Table 22.

A = Accretion flows downstream of the Keswick Dam can exceed 100% of maximum WUA for steelhead spawning in the portion of the Keswick reach available to anadromous fish and can exceed the predictive capability of the IFIM model. Accretion flows downstream of the Keswick Dam provide >90% of maximum WUA for steelhead rearing in the portion of the Keswick reach available to anadromous fish (Table 25).

F = On occasion the release is not attainable due to the quantity of inflow reaching North Battle Creek Feeder Diversion. Additional inflows to the North Battle Creek Feeder Reach are occasionally received from the junction box of the Volta 2 Powerhouse tailrace and Cross-Country Canal a short distance downstream.

S = Eagle Canyon Dam releases reported in this table include releases from Eagle Canyon Springs (those springs located downstream of Eagle Canyon Dam that were included in the “interim flow agreement” between PG&E and USBR; USBR 1998a).

N1 = The prescribed instream flow will be the natural flow arriving at the South Dam, minus 5 cfs, at times when the natural inflow is less than the optimum flow plus 5 cfs. A release of 5 cfs will be maintained in the South Canal at all times to preserve the physical integrity of the South Canal.

P1 = The prescribed instream flow will be the total available inflow in the South Fork upstream of the South Powerhouse at times when the available inflow is less than the optimum flow.

P2 = The prescribed instream flow will be the total available inflow in the South Fork upstream of the Inskip Powerhouse at times when the available inflow is less than the optimum flow.

Table 24. Summary of prescribed instream flow releases from diversions in tributaries affecting the anadromous reaches of Battle Creek and tributaries based on best available information.

Diversion	Monthly Minimum Flow (cfs) To Be Released From Tributary Diversions											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Eagle Canyon Spring	All ^{D,T}	All ^{D,T}	All ^{D,T}	All ^{D,T}	All ^{D,T}	All ^{D,T}	All ^{D,T}	All ^{D,T}	All ^{D,T}	All ^{D,T}	All ^{D,T}	All ^{D,T}
Soap Creek	10 ^S	10 ^S	10 ^S	10 ^{S,R,N3}	10 ^{S,R,N3}	All ^{S,R}	All ^R	All ^R	All ^R	All ^R	10 ^R	10 ^S
Lower Ripley Creek	3 ^{N2,S}	3 ^{N2,S}	3 ^{N2,S}	3 ^{N2,S}	3 ^{N2,S}	E	E	E	E	E	E	3 ^{N2,S}
Baldwin Creek	5 ^{S,C}	5 ^{S,C}	5 ^{S,C}	5 ^{S,C}	5 ^{S,C}	5 ^{S,C}	5 ^{R,C}	5 ^{R,C}	5 ^{R,C}	5 ^{R,C}	5 ^{R,C}	5 ^{S,C}

D = Flow from Eagle Canyon Springs enters Battle Creek in the vicinity of Eagle Canyon Dam and is included in Eagle Canyon Dam releases on Table 20.
 T = All flow from the springs near Eagle Canyon Dam that were included in the “interim flow agreement” between PG&E and USBR will be released to maximize cooling of Battle Creek (USBR 1998a).

N2 = The prescribed instream flow will be the natural inflow arriving at the Lower Ripley Creek Diversion at times when the natural inflow is less than the optimum flow.

N3 = The prescribed instream flow will be the natural inflow arriving at the Soap Creek Diversion at times when the natural inflow is less than the optimum flow.

S = Steelhead spawning flows.

R = Steelhead rearing flows.

C = The flow value reported for Baldwin Creek represents the maximum anticipated instream flow release and may be adjusted downward after a field trip by members of the BCWG Biological Team in the fall of 1998. Flow releases in Baldwin Creek would also be coupled with gravel enhancement and barrier modifications.

E = No change from existing conditions.

Table 25. Summary of two independent estimates of inflow at each dam in a typical water year assuming optimum flows in Table 23 and assuming no transfer of water from the North Fork to the natural channel of the South Fork. The first values were estimated by RMI (1998) and the second values were estimated by PG&E.*

Dam	Fork	Estimated Inflow (cfs) at Each Dam in a Typical Water Year Assuming Optimum Flows in Table 23 and Tailrace Connectors.† (RMI value/PG&E value)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Keswick	North	17/11	16/13	174/167	110/129	43/46	21/23	14/16	13/12	13/23	12/10	14/14	14/13
NBCF	North	54/46	47/54	267/147	161/164	74/89	60/81	43/42	37/34	39/50	33/38	41/51	42/41
Eagle	North	104/87	91/102	402/364	254/253	118/160	104/138	83/72	71/61	76/74	64/62	80/75	82/70
Wildcat	North	49/52	49/38	347/275	197/182	58/91	43/64	41/36	41/37	41/37	41/42	41/41	48/58
South	South	64/46	56/62	198/358	145/251	89/128	71/72	50/40	43/31	46/34	38/26	48/115	50/40
Inskip	South	79/80	69/92	190/533	120/398	83/204	77/119	62/57	52/44	55/51	46/32	59/34	61/55
Coleman	South	99/102	97/88	234/521	153/385	58/183	55/46	50/45	49/40	49/65	48/33	50/42	96/57

*The BCWG has selected 1989 as a typical water year for analysis and modeling. The RMI (1998) data entered in the table were derived using upstream drainage areas to apportion the total Battle Creek flow recorded at the USGS stream gage below CNFH. The PG&E data entered in the table were derived from both recorded and interpolated gage information at each of the sites for WY 1989.

† Tailrace connectors are proposed structures downstream of South and Inskip powerhouses that prevent tailrace water, comprised, in part, of water from the North Fork, from entering South Fork Battle Creek by directly conveying powerhouse tailwater to off-stream canals.

Flow Fluctuations

Operation of the Battle Creek Hydroelectric Project causes water level changes (ramps) in reaches of Battle Creek that are more rapid than those which occur naturally. Flow ramps typically occur for three reasons: 1) generation changes at powerhouses; 2) emergency powerhouse shutdowns; and 3) powerhouse and canal maintenance. Increases in flow (up-ramps) can cause short-term increases in turbidity and displace riparian organisms that don't have time to adjust their position to the higher flow. Decreases in flow (down-ramps) can strand juvenile fish and other aquatic organisms, de-water redds, and interfere with spawning activity (Hunter 1992).

The effects of ramping on the aquatic ecosystems of Battle Creek have not been directly studied though the BCWG has identified specified ramping rates as a necessary restoration action. Though recommended ramping rates of less than 0.17 feet/hour in Hunter (1992), based on comprehensive studies in the Skagit River (Seattle City Light 1989) and the Sultan River (Snohomish County PUD 1990), have been widely adopted at hydroelectric projects in Washington State and Oregon, the lack of large bedrock or alluvial flats in Battle Creek decreases the likelihood of fish stranding. A study of fish stranding and ramping rates specific to Battle Creek should be undertaken if ramping rates in excess of the Hunter (1992) standards are desired at the Battle Creek Hydroelectric Project. Current negotiations between PG&E and the resource agencies are expected to result in recommendations about ramping rates which should meet the principles outlined in Table 9.

Fish Passage at Dams

Fish ladders are necessary to assist migrating fish move upstream over dams and fish screens are necessary to prevent fish from being entrained into water diversions. Fish passage at dams can also be facilitated by removing or breaching dams. No fish screens are currently operational at the six hydroelectric dams (CDWR 1998). Existing fish ladders at the six hydroelectric dams in the anadromous fish habitat upstream of CNFH have been examined and determined to be inadequate for the restoration of salmon and steelhead to Battle Creek (CDFG 1996f).

Fish ladders at all six PG&E diversion dams within the anadromous reaches of Battle Creek have been modified over their lifetime (PG&E 1998b) though most of the existing ladders are undersized for necessary restoration flows and some are improperly configured (CDWR 1997, 1998). North Battle Creek Feeder Dam currently has a fish ladder at the center of the dam that cannot be maintained during high flow events. The present Alaska steppass ladder at Eagle Canyon is inadequate for fish restoration. A small Alaska steppass ladder, inserted into the original concrete step pool ladder at Wildcat Dam, is undersized and inefficient for fish restoration. South Dam currently has a denil fish ladder with a capacity of between 25 and 35 cfs. Though recently retrofitted, this ladder could be improved. An Alaska steppass ladder, inserted into portions of the original concrete step pool fish ladder, is located at the center of the Inskip Dam but it only carries 7 cfs and has long, steep sections. The fish ladder at Coleman Dam is an Alaska steppass ladder designed to carry a maximum of 7 cfs and has been deemed insufficient and undersized.

CDWR (1997, 1998) and USBR (1998c) have identified alternative restoration actions to improve fish passage at the six hydroelectric dams (Table 26). Tailrace connectors between the South Powerhouse and the Inskip Canal, and between the Inskip Powerhouse and Coleman Canal, are better able to meet the principles outlined in Table 9 than fish screens because they eliminate a series of fish screens which are less reliable and harder to maintain than pipelines, improve the quality of the main water supply for CNFH by helping to limit the presence of wild anadromous salmonids in water delivered to CNFH, and reduce the possibility of introducing stocked rainbow trout into anadromous stream reaches via the hydroelectric canal system. Installation of tailrace connectors could reduce the present, total screening capacity requirement for the anadromous reach of 800 cfs by 63 percent (500 cfs) without rescreening any waters. If a limited number of dams were decommissioned where there is low hydroelectric potential and high need for biological performance, then the volume of water needing to be screened could be reduced to about 85 percent of present screening needs. Current negotiations between PG&E and the resource agencies are expected to result in recommendations about fish passage, based on these two reports, which should meet the principles outlined in Table 9.

Table 26. Alternative restoration actions to improve fish passage at the six hydroelectric dams in the anadromous fish habitat of Battle Creek upstream of CNFH.

Site Name	Restoration Alternative	Approximate Cost ²³
North Battle Creek Feeder Dam	55 cfs fish screen	\$585,000
	Fish ladder	\$630,000
Eagle Canyon Dam	70 cfs fish screen	\$1,098,000
	Fish ladder	\$1,028,000
	Dam removal	\$2,900,000
	Partial dam removal	\$1,470,000
Wildcat Dam	20 cfs fish screen	\$425,000
	Fish ladder	\$620,000
	Dam removal	\$3,000,000
	Partial dam removal	\$1,610,000
South Dam	90 cfs fish screen	\$3,000,000
	Retrofit existing fish ladder	\$100,000
	New fish ladder	\$770,000
Inskip Dam	80 cfs fish screen	\$1,045,000
	Fish ladder	\$1,050,000
	Tunnel tailrace connector	\$4,000,000
Coleman Dam	Tailrace connector	\$2,600,000
	340 cfs fish screen	\$2,080,000
	60 cfs fish screen	\$685,000
	Fish ladder	\$857,000
	Dam removal	\$930,000
	Partial dam removal	\$620,000

²³ Estimated costs were obtained from CDWR (1997, 1998) and USBR (1998c) as well as revisions provided to PG&E and the resource agencies at negotiations on October 28, 1998, December 10, 1998, and December 23, 1998.

Straying and False Attraction

The present hydropower water conveyance system diverts water from North Fork Battle Creek, primarily at North Battle Creek Feeder Dam and Eagle Canyon Dam, into South Fork Battle Creek at South and Inskip powerhouses (Figure 3). Water from the both forks of Battle Creek is diverted downstream to the mainstem Battle Creek at the Coleman Powerhouse, via the Coleman Canal (Figure 3). These water diversions have potentially negative implications for the restoration of anadromous salmonids in Battle Creek, primarily by confounding the ability of migrating adults to properly home to their natal spawning grounds.

Homing is the ability of salmon and steelhead to return, usually precisely, to the stream or stream reach where they were spawned and reared (Quinn 1997). The mechanisms allowing salmonids to properly home generally stems from the ability of salmon to recognize olfactory characteristics of their home stream (Hasler and Scholz 1983). Juvenile salmonids imprint on, or “remember,” the smell of organic compounds that are uniquely characteristic of a given stream or stream reach, and use these odors as adults to find their way back to where they were reared. Homing may be influenced by such factors as flow, water temperature, presence of other salmon, and habitat quality (Pascual and Quinn 1994; Quinn 1997). For instance, the homing precision of salmon increases with the relative magnitude of stream flow present in home stream (Hindar 1992).

Conversely, straying is the term used to indicate when a migrating salmon does not return to their home stream or stream reach (Quinn 1997). From an evolutionary standpoint, straying provides the opportunity to colonize new habitats (Milner and Bailey 1989) and promotes genetic heterogeneity at the population level (Utter 1991). On an individual basis, homing is more likely to lead to successful spawning because the homing fish can “predict” the presence of good quality spawning and rearing habitat in their home stream (the habitat obviously was good enough to rear the migrating fish) compared to the gamble associated with straying to an unknown stream with unknown habitat quality.

Two straying and false attraction problems have been identified in Battle Creek. The first situation occurs at the Coleman Powerhouse tailrace where salmon and steelhead are attracted to the water discharged from the powerhouse. Fish attempt to spawn in the habitat immediately below the powerhouse or spend unnecessary energy attempting to migrate upstream in the tailrace. This false attraction is likely a combination of rheotactic and olfactory responses. As noted above, this situation may be remedied by the construction of an interim barrier to prevent fish from migrating into the Coleman Powerhouse tailrace (USBR 1998a).

The second straying problem arises as a result of the inter-basin transfers of water from the North Fork to the South Fork. This diverted water presumably contains sufficient quantities of odors from the North Fork to confuse migrating adults which are choosing between the North Fork and South Fork. In other words, an adult chinook salmon spawned and reared in the North Fork, that is returning to Battle Creek and choosing between the North Fork and South Fork, is more likely to choose the wrong stream if it is able to identify the scent of North Fork water in the South Fork stream channel.

Such a mistaken choice could be very stressful, if not lethal, in Battle Creek. In particular, adult winter- and spring-run chinook salmon inhabit Battle Creek at times when water temperatures in the lower portion of the South Fork can be too high for successful spawning or survival. Though excellent habitat with cool water temperatures exists in the upper South Fork, the two powerhouses discharging cooler North Fork water are relatively low in the system. Therefore, North Fork fish straying to the South and Inskip powerhouse tailraces on the South Fork would likely be faced with poor water quality. These fish would be in further jeopardy because constant flow from the powerhouses is not reliable in light of powerhouse outages.

Winter- and spring-run chinook in the North Fork are most likely to rear downstream of North Battle Creek Feeder Dam and upstream of Eagle Canyon Dam. This means that these fish would more likely be confused by water diverted at Eagle Canyon Dam than water diverted at North Battle Creek Feeder Dam. Water from the upper dam flows far enough to acquire additional unique odors between the dam and the rearing sites. Therefore, though both diversions may be problematic, mixing water from Eagle Canyon Dam with South Fork water is more likely to cause straying than water diverted at North Battle Creek Feeder Dam (Dr. Tom Quinn, University of Washington, Seattle, Wa., pers. comm.).

Similar situations have caused concern elsewhere, though the problem is difficult to scientifically document. Salmon returning to the Skokomish River in Washington State may suffer from delays in migration, and possible mortality, when they are falsely attracted to water diverted from the river and conveyed out of the basin to a powerhouse (Dr. Tom Quinn, University of Washington, Seattle, Wa., pers. comm.). In New Zealand, a population of fall-run chinook salmon (originally obtained from Battle Creek, California, in the early 20th century) apparently strays at a rate of about 20 percent in a situation where an inter-basin water transfer takes place (Dr. Tom Quinn, University of Washington, Seattle, Wa., pers. comm.). Indeed, such straying may be common but remains unrecognized because it is hard to quantify, especially in naturally-produced fish (Quinn 1984, 1997).

As stated above, homing will generally be more precise in the presence of higher flows. This implies that higher instream flow in the lower North Fork would assist the proper homing of North Fork-reared salmonids. Homing is also expected to be more precise in populations that are reared in stable habitat (Quinn 1984, 1997). Therefore, it is important to pursue restoration actions which promote stable habitats in the North Fork rather than develop conditions which fluctuate, are unstable from year to year, or that depend on mechanical systems prone to outages or malfunctions, in order to minimize potentially problematic straying in restored Battle Creek fish populations.

Two restoration actions can be taken to eliminate the possibility of straying induced by inter-basin diversions. The diversions could be eliminated or tailrace discharges could be rerouted to prevent North Fork water from entering South Fork Battle Creek. CDWR (1998) reported that tailrace connectors below the South and Inskip powerhouses are feasible and would cost approximately \$4,000,000 and \$2,600,000, respectively. Removal of Eagle Canyon and Wildcat dams, without installation of tailrace connectors, would also reduce false attraction problems, though not to the maximum extent, especially if coupled with reductions in water diversions at North Battle Creek Feeder Dam. Current negotiations between PG&E and the resource agencies

are expected to result in recommendations about mechanisms to reduce straying which should meet the principles outlined in Table 9.

Natural Barriers

A study of natural barriers to fish migration in 1989 identified 26 barriers within the two forks of Battle Creek (TRPA 1998b). One impassable barrier in the Eagle Canyon Reach has since been modified to allow fish passage and others have changed configuration since the 1989 field studies, implying that new barriers may have formed. Most natural barriers were estimated to be passable at flows between 20 and 50 cfs but 30 cfs was estimated to be the minimum flow necessary for fish passage. TRPA (1998b) recommended that physical modification of natural barriers be coupled with at least 30 cfs flow. However, this is a minimum flow recommendation and does not guarantee that new or future natural barriers will not require more water for efficient fish passage. Current negotiations between PG&E and the resource agencies are expected to result in recommended instream flow releases that will provide at least 30 cfs for fish passage and which should meet the principles outlined in Table 9. These increased minimum flows should be complemented with periodic barrier surveys, especially after large storm events which mobilize large stream substrate that can form new barriers, and, potentially, physical modification of new barriers.

A barrier in South Fork Battle Creek that was not identified in TRPA (1998b) exists upstream of South Dam near Panther Creek and forms the present upstream limit to salmon and steelhead distribution in the watershed. If this barrier was modified, approximately 2.5 miles of additional anadromous fish habitat, a watershed-wide increase of 6 percent, would be opened to salmon and steelhead.

Barriers to the migration of steelhead have been identified on Baldwin Creek that block approximately 2 miles of habitat. Modification of these barriers, coupled with gravel enhancement and increased instream flows, would provide steelhead with spawning sites protected from floods or catastrophes that might impact populations in the mainstem and the forks of Battle Creek.

Water Temperature

Water temperatures in Battle Creek under existing FERC minimum flows of 3 cfs for the North Fork and 5 cfs for the South Fork can be stressful or lethal to incubating, rearing and holding anadromous salmonids depending on season, water year, and location within the watershed (see Electronic Appendix KRIS-Battle for graphical representations of all temperature records available in the Battle Creek watershed). However, in some years and during some months, especially during the wet season, existing water temperatures under FERC minimum flows are sufficient for the most sensitive species and life stages in the restricted spring-fed reaches these species are likely to use (e.g. Figure 9, Figure 10, Figure 13, and Figure 14).

Interim flows of 30 cfs in the Eagle Canyon, Wildcat and Coleman reaches (USBR 1996) have demonstrated that routing cool stream and spring water down the natural stream channel, instead of in the hydroelectric project canals, can keep contiguous stream reaches of the North Fork sufficiently cool to allow holding, spawning, and rearing of winter- and spring-run chinook salmon (e.g. Figure 20; see USFWS 1997a, 1997b for documentation of spring- and winter-run utilization of this habitat).

Two temperature models have been partially completed that predict water temperatures in Battle Creek under various restored flow regimes (TRPA 1998c and 1998d; and PG&E 1999). These show relative stream temperature regimes among reaches where the temperature-sensitive species (i.e. winter-run and spring-run) reside. Restoring biologically-optimum stream and spring flow conditions will provide expanded and connected reaches of the stream that will support holding, spawning, and incubation of the sensitive species compared to the FERC flows, and will approximate historical, pre-project conditions. Water temperatures will also be sufficient for all life stages of steelhead, and fall- and late-fall-run chinook under restored conditions. The available temperature models are limited in that they are not applicable for determining absolute water temperatures though they may be useful for showing relative water temperature regimes among reaches.

Water temperatures in a restored Battle Creek during the warm season could be manipulated in two ways: 1) increasing instream and spring flows, during the warm season, to levels mimicking pre-hydroelectric project conditions, that will keep cold water in the stream channel and available for fish, or 2) diverting cold water from one reach or stream to another using the existing hydroelectric canal system. As noted in the previous section on “Instream Flow,” the BCWG’s Biological Team determined restored instream flow levels based primarily on habitat requirements for target fish species and available flows during the dry season. However, results of hydrologic models, as well as water temperatures observed under interim instream and spring flows for the North Fork, indicate that biologically-optimum flows would provide a water temperature regime similar to the historical, pre-project temperature regime and that is suitable for all target species and life stages in the reaches that these fish are expected to use.

For example, during summer in the mid- to high-elevation reaches of South Fork Battle Creek, those reaches that provide habitat for temperature-sensitive early life stages of anadromous fish, the biologically-optimum instream and spring flows approximate the average natural flows and, hence, approximate the temperature regime of the stream prior to any hydroelectric development. In reaches of the North Fork dominated by cold, spring-water accretions, the recommended flows exceed those empirically shown to provide adequate temperatures for the early life stages of anadromous fish during the 1995 to 1998 interim flow agreement which included both above normal and below normal water years (Figure 20). Furthermore, decommissioning of the lowest elevation dams in the system, an alternative found to be feasible by the USBR (1998c), would further maximize this method of temperature control by leaving in the stream all ground and surface water accretions from above these dams.

The second possible capability for managing water temperatures in Battle Creek would be the diversion of cold water from one reach to another or one fork to another using the hydroelectric canal system. For example, low-elevation portions of the South Fork, downstream of South and Inskip powerhouses, are presently cooled by the addition of North Fork water to the South Fork at South and Inskip powerhouses, as well as the addition of South Fork water delivered to these powerhouses from the South, Inskip, Soap Creek, and Ripley Creek diversions. However, model results from the PG&E SNTMP model, showing relative changes in water temperatures, indicate that the artificial cooling of the South Fork occurs in only the upper-most portions of the Inskip and Coleman reaches. The cooled water warms quickly in these portions of

the South Fork where the climate is hot due to the low elevation and lack of topographical shading.

Several other problems with the use of diversions to manipulate stream temperatures suggests that it is not applicable or would not lead to successful restoration of Battle Creek. First, a similar approach proposed by PG&E on Butte Creek, to provide cool water to a smaller habitat area downstream of the Centerville Powerhouse rather than providing habitat in the lengthy Centerville bypass reach, was rejected by FERC (1991). This suggests that the approach of using water diverted from high-elevation reaches of South Fork Battle Creek to cool temperatures in low-elevation reaches, downstream of South and Inskip powerhouses, would be similarly rejected. Second, diversion of water from the North Fork to the South Fork would likely lead to the false attraction of fish spawned in the North Fork to the low elevation reaches of the South Fork, a condition which would reduce the survival of these fish over what they could achieve in the North Fork or upper reaches of the South Fork. Further false attraction could occur if South Fork fish migrating upstream to naturally cool habitat were distracted by the artificially cool water in these lower-elevation reaches. All fish falsely-attracted to the artificially cool pockets would be especially susceptible to stressful or lethal conditions that could occur during powerhouse or canal outages. Third, though water below the South and Inskip powerhouses could be cooled, there is no net gain in cool water habitat considering that this cool water is being taken from other stream reaches that would otherwise function naturally to produce fish. Fourth, these artificially cool patches violate principles of ecosystem function (Cairns 1990) because they are isolated from large, stable, and cool habitat that naturally occurs in higher-elevation reaches, they disrupt the natural thermal gradients existing in functional streams which cue fish to distribute themselves to the best habitat at the proper times, and they are based on mechanical systems subject to failure or disruption.

Of the two ways that water temperatures can be influenced in Battle Creek, increasing instream and spring flows to approximate natural flow conditions during the warm season appears to be the most certain and effective way of providing stable, cool-water habitat that meets the goals of restoring ecosystem function. Current negotiations between PG&E and the resource agencies are expected to result in recommended instream flow and spring-water releases that will provide a water temperature regime similar to pre-project conditions when the stream was a fully functioning ecosystem. Restoration actions determined in these negotiations should meet the principles outlined in Table 9.

Gravel Management

Field work conducted for CDFG in 1989 quantified the amount of gravel which exists in Battle Creek from the Coleman Powerhouse upstream to the upper-most natural barrier on the North Fork and the South Dam on the South Fork (Table 27; CDFG 1995c). No human induced actions have been identified that limit the amount of gravel present in the anadromous portion of the watershed upstream of CNFH, though gravel routing is interrupted by the 6 hydroelectric diversion dams. PG&E, at the request of CDFG, has voluntarily passed gravel over the dams during dredging operations when removing gravel from diversion pools.

Gravel movement past existing diversion dams is accomplished by flushing sediment through the low level outlet at the base of the dams or by mechanically removing the material. Flushing sediments through the dam outlet is accomplished by opening the outlet during high spill flows and closing the outlet as high flows recede. This method is preferred by PG&E (PG&E 1998b).

Due to its natural configuration, Baldwin Creek is low in spawning gravel resources. Artificial supplementation of gravel in Baldwin Creek has been suggested as a way to increase steelhead populations in this stream if gravel enhancement is coupled with increased instream flows and barrier modification.

Dam removal or active movement of gravel over dams are actions which are necessary for the restoration of salmonids in Battle Creek. Dam removal would restore ecosystem processes that naturally route gravel in the watershed while dredging and stockpiling gravel has less certainty because it would require periodic monitoring and equipment and labor costs. Current negotiations between PG&E and the resource agencies are expected to result in restoration actions that will provide for gravel routing using an ecosystem based restoration approach and should meet the principles outlined in Table 9.

Table 27. Amount of spawning gravel in several reaches of Battle Creek in 1989.

Stream and Reach	Amount of Spawning Gravel (sq. ft.)
North Fork – Keswick	5,700
North Fork – North Battle Creek Feeder	25,700
North Fork – Eagle Canyon	26,000
North Fork – Wildcat	21,700
South Fork – South	12,200
South Fork – Inskip	14,200
South Fork – Coleman	5,500
Mainstem – Mainstem	58,600

Control of Disease Transmission

Concern for disease-transmission between wild populations of chinook salmon and populations rearing at CNFH have been alleviated by the construction and operation of an ozone treatment facility that will purify hatchery intake water (USFWS 1998f). However, reliance on the ozone treatment system to control disease transmission fails to meet restoration principles listed by the resource agencies (Table 9) and does not meet the ecosystem approach to restoration mandated by CalFed and CVPIA, as described earlier in this document, primarily because the ozonation system is a mechanical system prone to malfunctions, outages, and required maintenance, especially when considered in perpetuity. Furthermore, closing fish ladders and limiting salmon migration at Wildcat and Coleman Dams and blocking access of all fall- and late-fall-run chinook salmon at the CNFH barrier dam, actions taken in the past to control the distribution of infected fall- and late-fall-run chinook, will not be feasible in the future once

significant, populations of salmon are restored to the watershed, especially if fall-run chinook salmon are listed under the federal ESA.

Fortunately, several restoration actions under consideration in the anadromous habitat upstream of CNFH would serve as redundant, fail-safe disease-controlling mechanisms for the CNFH in case the ozonation system were to malfunction. For example, if Wildcat, Eagle Canyon and Coleman Dams are removed, and tailrace connectors are installed at South and Inskip powerhouses, then the lowest diversion point in the North Fork would be shifted from Wildcat Dam (elev. 1074') to North Battle Creek Feeder Dam (elev. 2091'), a point in the watershed above which fall-run and late-fall-run chinook salmon are not expected to spawn. In the South Fork, the lowest diversion point would shift from Coleman Dam (elev. 1017') to Inskip (elev. 1435'). Again, these actions would shift the lowest water diversion in the South Fork upstream above areas where large numbers of fall- and late-fall-run chinook salmon would be expected to spawn. As long as infected fish remain downstream of water diversions that serve as water supplies for CNFH, disease transmission will be prevented even if the ozonation system should happen to fail.

Battle Creek Anadromous Fish Habitat Downstream of CNFH

In light of the changing nature of the watershed under existing and proposed restoration scenarios, the BCWG has convened a scientific panel to examine the challenges and opportunities associated with operations of CNFH, with special emphasis on operation of the barrier dam. Sections of this report dealing with anadromous fish habitat downstream of CNFH will be completed in a future edition or addendum to this report.

Ecological Integration of Coleman National Fish Hatchery

In light of the changing nature of the watershed under existing and proposed restoration scenarios, the BCWG has convened a scientific panel to examine the challenges and opportunities associated with operations of CNFH, with special emphasis on operation of the barrier dam. Sections of this report dealing with ecological integration of CNFH will be completed in a future edition or addendum to this report.

RECOMMENDATIONS

Recommendations in this section have been developed more fully in the Technical Plan section of this document. As noted above, specific restoration actions that involve PG&E's Battle Creek Hydroelectric Project facilities will be decided in ongoing negotiations between PG&E and resource agencies (these actions will be indicated with a "†" symbol). All recommendations are based on best available information documented in this report and on a set of principles that the resource agencies have identified as essential for salmonid restoration and as a necessary component of any negotiated settlement (Table 9). The recommendations assume that restoration actions funded with public environmental funds must provide greater biological benefits and more ecological certainty than those actions which would be required under current regulatory requirements.

Recommendations are divided into actions, suggested evaluations and studies, and monitoring. Within each of these broad topics, recommendations are organized geographically, and by topic within geographic areas. Note that recommendations for anadromous habitat downstream of CNFH and for ecologically integrating CNFH into the restoration program will be deferred until after a BCWG subcommittee analyzes data relevant to these two areas.

Actions Necessary for Salmonid Restoration

Battle Creek Uplands

- Encourage conservation easements and other incentives to retain large blocks of land under private ownership that continue to buffer Battle Creek fish populations from intense types of streamside land management practices and human disturbance.
- Encourage land management to protect against catastrophic wildfires through fuel reduction.

Battle Creek Upstream of Anadromous Fish Habitat

- Encourage conservation easements and other incentives to retain large blocks of land under private ownership that buffer Battle Creek fish populations from land management practices and human disturbance.
- Encourage riparian, stream channel, and fish habitat restoration projects following ecosystem-based approaches on private lands.
- Prevent groundwater exports from the Battle Creek watershed.
- Conduct a coordinated watershed assessment on public and private lands to identify sources and remedies for sediment delivery to Battle Creek.

Anadromous Fish Habitat upstream of CNFH

- † Increase instream flows below PG&E diversion dams on the forks of Battle Creek and identified tributaries, following an ecosystem-based approach, to fully mitigate for loss of streamflow caused by the diversions and to allow full recovery of the sensitive species of anadromous fish in these stream reaches. The flows believed to attain these objectives are identified as the biologically-optimum flows (Table 23 and Table 24) and they are estimated to generally provide 95 percent of theoretically usable habitat, adequate passage over barriers, and sufficient water temperatures. The recommended flows are based on the best available information at this time and meet the principles detailed in Table 9.
- Dedicate the water reallocated from power production to fish restoration and instream uses in perpetuity to prevent future reallocation to off-stream uses.
- † Establish ramping rates of less than 0.17 feet/hour (Hunter 1992) that meet the intent of State and federal endangered species laws (i.e. to fully mitigate any stranding or isolation of fish related to ramping) using all relevant information, and that meet the principles detailed in Table 9.
- † Install pipeline connections between powerhouses and diversion-canal intakes to prevent trans-basin water diversions from causing false attraction of anadromous salmonids from the North Fork to the South Fork.
- † Following an ecosystem-based approach, choose from alternative actions listed in Table 26 that optimize fish passage at all PG&E diversion dams and that meet principles detailed in Table 9. Dam decommissioning is the recommended restoration action in cases where the costs to install, operate, maintain, and replace screens and ladders on dams in perpetuity exceeds the one time cost to decommission a dam and to pay present value for the forgone power. In cases where screens and ladders are installed on diversions instead of dam removal or pipeline connectors between powerhouses and canals, establish methods for daily remote monitoring, cleaning, repairing and replacement of fish ladders and screens.
- Complete a permanent tailrace barrier at the Coleman Powerhouse tailrace.
- Modify the barrier to fish migration at Panther Creek on the South Fork in order to open an additional 2.5 miles of anadromous salmonid habitat.
- Modify barriers to steelhead migration on Baldwin Creek in order to open additional steelhead habitat.
- Supplement spawning gravels for steelhead in Baldwin Creek.
- † Implement pipeline connections and dam removals to minimize the flow of fish pathogens from salmon habitat to the CNFH's primary water supply on Coleman canal

to provide redundant disease safety for the water supply during times when the ozonation system is inoperative.

- † Establish institutional controls and automated mechanisms that insure that water diversions are halted during periods when fish screens are inoperative, and that insure compliance with instream flow requirements and ramping rates.

Evaluations and Studies Necessary for Salmonid Restoration

Battle Creek Upstream of Anadromous Fish Habitat

- As part of the BCWC process, commission a study of groundwater resources in the upper watershed and their connectivity with springs and seeps in anadromous fish habitat and commission a locally developed groundwater management plan which identifies and prevents potential threats to the groundwater system in Battle Creek.
- Evaluate the genetic effects of large-scale stocking of hatchery rainbow trout on steelhead populations and take appropriate measures to insure no negative genetic effects of stocking on steelhead.

Anadromous Fish Habitat Upstream of CNFH

- In the case that the ramping rates implemented to prevent stranding of fish are less protective than those recommended by Hunter (1992), conduct a study to determine if identical fish loss rates can be achieved. Because the stream system currently has only remnant populations of fish, the study sites must be saturated with test fish to have sufficient observations. Test fish should demonstrate equivalent behavior as wild fish.

Monitoring Necessary for Salmonid Restoration

Monitoring programs demonstrate the effectiveness of various restoration actions, especially those mitigation measures required for listed species and the amended FERC license. These efforts will initially be intensive and can be used to determine the efficacy of restoration

Battle Creek Uplands

- Monitor water quality and water temperature in tributaries to Battle Creek used for agricultural purposes or that drain residential areas, preferably with a coordinated, locally-developed monitoring program.

Battle Creek Upstream of Anadromous Fish Habitat

- Monitor water quality and water temperature in tributaries to Battle Creek used for agricultural purposes or that drain residential areas, preferably with a coordinated, locally-developed monitoring program.
- Monitor the success of private habitat restoration efforts.

Anadromous Fish Habitat Upstream of CNFH

- Monitor and report compliance with instream flow requirements for the life of the hydroelectric project.
- Monitor stream flows at the North and South forks upstream of the confluence of the two forks and at the USGS stream gage downstream of CNFH in perpetuity.
- Monitor and report compliance with ramping rate requirements for the life of the hydroelectric project.
- Monitor water temperatures at 25 stations at the start and end of each stream reach and at the mouths of tributaries for a 5 year period after implementation of restored flow regimes in Battle Creek unless water temperature problems are identified and the continuation of temperature monitoring is justified. Periodically repeat this temperature monitoring program.
- Monitor air temperature at a mid-elevation weather station because air temperature is the biggest influence on water temperature and there is presently no representative air temperature stations nearby.
- Monitor streams for the formation or reconfiguration of natural barriers to fish migration, especially after high flow events, and take appropriate steps to insure fish passage at newly formed fish barriers.
- Monitor daily the operation of all fish passage facilities and maintain, repair or replace as needed during the life of the hydroelectric project.
- Monitor counts of adult salmon and steelhead that migrate into the watershed until the coordinated goals established by CalFed and CAMP are met.

- Monitor the abundance and distribution of salmon and steelhead redds within the watershed until the coordinated goals established by CalFed and CAMP are met.
- Monitor the abundance, distribution, and emmigration timing of juvenile salmon and steelhead until the coordinated goals established by CalFed and CAMP are met.
- Monitor diseases in wild fish until the coordinated goals established by CalFed and CAMP are met.
- Monitor genetic characteristics of the four runs of salmon until the coordinated goals established by CalFed and CAMP are met.
- Monitor the tagging of hatchery product and evaluate the effectiveness of this tagging for as long as tagging of fish is implemented.
- Continue and expand the use of present data management and information sharing tools (e.g. KRIS-Battle Creek) to facilitate information exchange between policy makers, stakeholders, and residents of the watershed, and to assist in all aspects of physical and biological monitoring, until such a time that vital ecosystem processes have been established and fish populations have responded.

LITERATURE CITED

- Angermeier, P.L. and J.R. Karr. 1994. Biological integrity versus biological diversity as policy directives: protecting biotic resources. *BioScience* 44:690-697.
- Anonymous. 1989. Chronology of events, Battle Creek fishery, 1988-1989. *In*: Battle Creek Project (FERC No. 1121) Resource Agency and PG&E coordination meeting regarding fish flow/hatchery needs, May 2, 1989.
- Armour, C.L. 1991. Guidance for evaluating and recommending temperature regimes to protect fish. USFWS, Fort Collins, Co. Instream Flow Investigation Paper 28: Biological Report 90(22).
- Bartholow, J.M., J.L. Laake, C.B. Stalnaker, and S.C. Williamson. Unpublished proof of manuscript: A salmonid population model with emphasis on habitat limitations. Submitted to *Rivers* 4(3).
- Bay Institute, The. 1998. From the Sierra to the sea: the ecological history of the San Francisco Bay-Delta watershed. The Bay Institute, San Rafael, California.
- BCWG (Battle Creek Working Group). 1998. Draft discussion paper: Time for Action. Prepared by a subgroup of the BCWG that did not include PG&E.
- Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monograph No. 6.
- Berejikian, B. 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry (*Oncorhynchus mykiss*) to avoid a benthic predator. *Can. J. Fish. Aquat. Sci.* 52:2476-2482.
- Berejikian, B. 1996. Effects of hatchery and wild ancestry and rearing environments on the development of agonistic behaviour in steelhead trout (*Oncorhynchus mykiss*) fry. *Can. J. Fish. Aquat. Sci.* 53:2004-2014.
- Berger, J.J., ed. 1990. Environmental restoration: science and strategies for restoring the Earth. Island Press, Washington, D.C.
- Bernard, D.P., A. Gunther, E. Laychak, C. Darling. 1996. Restoring Central Valley spring-run chinook salmon populations: Technical workshop to identify candidate programs and projects for Category III funding. Category III Steering Committee and CALFED Bay-Delta Program.
- Black, M. 1997. Draft A brief history of salmon mitigation efforts surrounding Coleman National Fish Station on Battle Creek, 1895 - 1992. Kier Associates, Sausalito, California.

- BLM (U.S. Bureau of Land Management). 1998. Memo to Tim Livingstone, Harry Rectenwald, Randy Benthin, Tricia Parker, and Phil Schoefer from Francis Berg, USBLM: Assessment of management alternatives for the Battle Creek canyon corridor, February 2, 1998. U.S. Bureau of Land Management, Redding, California.
- Bradbury, W., W. Nehlsen, T.E. Nickelson, K. Moore, R.M. Hughes, D. Heller, J. Nicholas, D.L. Bottom, W.E. Weaver, and R.L. Beschta. 1995. Handbook for prioritizing watershed restoration to aid recovery of native salmon. Pacific Rivers Council, Portland, Oregon.
- Bugert, R.M. 1998. Mechanics of supplementation in the Columbia River. *Fisheries*. 23(1):11-20.
- CACSST (California Advisory Committee on Salmon and Steelhead Trout). 1988. Restoring the balance: 1988 Annual Report. California State Capitol, Sacramento, California.
- Cairns, J. Jr. 1990. Lack of theoretical basis for predicting rate and pathways of recovery. *Environmental Management*. 14:517-526.
- CalFed. 1998. CalFed Bay-Delta Program Ecosystem Restoration Program Plan Volume I Programmatic EIS/EIR Technical Appendix March 1998. 350 pages.
- CAMP (Comprehensive Assessment and Monitoring Program). 1997. Comprehensive Assessment and Monitoring Program (CAMP) implementation plan: a comprehensive plan to evaluate the effectiveness of CVPIA actions in restoring anadromous fish production. USFWS, Sacramento, California.
- CAMP (Comprehensive Assessment and Monitoring Program). 1998. Annual Report, 1995-1997. USFWS, Sacramento, California.
- CDFG (California Department of Fish and Game). 1951. Memorandum dated November 2, 1951 regarding handling of fish at Coleman hatchery signed Donald Fry
- CDFG (California Department of Fish and Game). 1961. King salmon spawning stocks of the California Central Valley, 1940-1959 *Cal. Fish and Game Quarterly* 47(1): 55-71.
- CDFG (California Department of Fish and Game). 1965a. California fish and wildlife plan: Volume III, Part B - Inventory of salmon-steelhead and marine resources. 1051 pp.
- CDFG (California Department of Fish and Game). 1965b. Memorandum dated May 26, 1965 regarding a creel census in Battle Creek signed by J. R. Adams. On file in CDFG, Region 1 Office, Redding, California.
- CDFG (California Department of Fish and Game). 1966. Pacific Gas and Electric Company's Battle Creek System Power Project, Minor Part License Number 1121. 32pp.
- CDFG (California Department of Fish and Game). 1968. Progress report on a study of logging in the North Fork Battle Creek. On file in CDFG, Region 1 Office, Redding, California.
- CDFG (California Department of Fish and Game). 1969. Memorandum to Elton D. Bailey regarding the North Fork Battle Creek, Shasta County, Logging Study – 1968 progress report. 3 pp.

- CDFG (California Department of Fish and Game). 1970a. Daily Activity Report for Screen Shop.
- CDFG (California Department of Fish and Game). 1970b. The gross effects of temporary stream bank erosion control measures on the aquatic environment of Battle Creek, Shasta and Tehama Counties. CDFG.
- CDFG (California Department of Fish and Game). 1970c. Letter to Robert Pollock, USFWS, from R. J. O'Brien, CDFG, dated August 18, 1970. On file in PG&E archives.
- CDFG (California Department of Fish and Game). 1972. Letter to D. Jack Darley from E.C. Fullerton, dated April 11, 1972. On file in CDFG, Region 1 Office, Redding, California. 2pp.
- CDFG (California Department of Fish and Game). 1978. Correspondence to Mr. D.B. Draheim, California Fisheries Restoration Foundation, Oakland, California, from A.E. Naylor. Dated January 31, 1978. On file in CDFG, Region 1 Office, Redding, California. 2pp.
- CDFG (California Department of Fish and Game). 1985. Regulation proposal. On file in CDFG, Region 1 Office, Redding, California.
- CDFG (California Department of Fish and Game). 1987. Fish rescue at Macumber Lake – October 4, 1987. Memorandum on file in CDFG, Region 1 Office, Redding, California. 1p.
- CDFG (California Department of Fish and Game). 1990. Central Valley salmon and steelhead restoration and enhancement plan. California Dept. Fish and Game. 115 pp.
- CDFG (California Department of Fish and Game). 1993a. Final report - Battle Creek spawning restoration project. CDFG.
- CDFG (California Department of Fish and Game). 1993b. Memorandum: Battle Creek fisheries management plan. CDFG. 3 pp.
- CDFG (California Department of Fish and Game). 1993c. Restoring Central Valley streams: A plan for action. California Department of Fish and Game.
- CDFG (California Department of Fish and Game). 1994a. Central Valley anadromous sport fish annual run-size, harvest, and population estimates, 1967 through 1991. California Department of Fish and Game Inland Fisheries Technical Report.
- CDFG (California Department of Fish and Game). 1994b. Memorandum to files: Screening of Orwick Diversion - Battle Creek, November 10, 1994. CDFG.
- CDFG (California Department of Fish and Game). 1994c. Central valley anadromous sport fish annual run-size, harvest, and population estimates, 1967 through 1991. Third Draft Inland Fisheries Technical Report August 1994. 70 pp
- CDFG (California Department of Fish and Game). 1995a. Letter to R. John Sandhofner, PG&E, from Richard Elliot, CDFG, April 7, 1995. CDFG files.

- CDFG (California Department of Fish and Game). 1995b. Memorandum to Kellye Kennedy, U.S. Bureau of Reclamation from Dave Hoopaugh, California Department of Fish and Game, July 18, 1995. CDFG.
- CDFG (California Department of Fish and Game). 1995c. Internal memorandum from Dave Hoopaugh to Harry Rectenwald on January 10, 1995. On file at CDFG, Redding, California.
- CDFG (California Department of Fish and Game). 1996a. Letter to Nancy Quan, Metropolitan Water District of Southern California, from Richard Elliot, CDFG, October 21, 1996. CDFG.
- CDFG (California Department of Fish and Game). 1996b. Letter to Robert Koch, NMFS, from Timothy C. Farley, CDFG, November 14, 1996. California Department of Fish and Game, Inland Fisheries division, Sacramento, California.
- CDFG (California Department of Fish and Game). 1996c. Steelhead restoration and management plan for California. California Department of Fish and Game. 234 pp.
- CDFG (California Department of Fish and Game). 1996d. Chinook salmon spawning stocks in California's Central Valley, 1985. Inland Fisheries Branch Administrative Report No. 96-4.
- CDFG (California Department of Fish and Game). 1996e. The 1996 Status of Sacramento River spring-run chinook salmon. A special Report to the Fish and Game Commission Pursuant to Section 670.6 of Title 14, CCR. CDFG, Inld. Fish. Div. 28pp.
- CDFG (California Department of Fish and Game). 1996f. Letter to Thomas Keegan, EIP, from Richard Elliot, CDFG on November 11, 1996. On file at CDFG, Redding, California.
- CDFG (California Department of Fish and Game). 1997a. The 1997 Status of Sacramento River spring-run chinook salmon. A special Report to the Fish and Game Commission Pursuant to Section 670.6 of Title 14, CCR. CDFG, Inld. Fish. Div. 28pp.
- CDFG (California Department of Fish and Game). 1997b. Letter to Dick Jewell, USFWS, from Richard Elliot, CDFG, on April 18, 1997: Comments on draft EA for Coleman water supply. CDFG, Redding, California.
- CDFG (California Department of Fish and Game). 1997c. California Wildlife Habitat Relationships System Printout for the Battle Creek Watershed.
- CDFG (California Department of Fish and Game). 1997d. Letter to interested parties from Richard Elliot, CDFG, on May 28, 1997. CDFG, Redding, California.
- CDFG (California Department of Fish and Game). 1997e. Memorandum to Division Chiefs and Regional Managers from Deputy Director A. Petrovich, Jr. regarding revised fish screening criteria, April 14, 1997. CDFG. On file at CDFG, Redding, California.
- CDFG (California Department of Fish and Game). 1997f. Letter to Jean Oscamou, PG&E, from Richard Elliot, CDFG, on April 23, 1998. CDFG. On file at CDFG, Redding, California.

- CDFG (California Department of Fish and Game). 1997g. Central Valley anadromous fish-habitat evaluations: Sacramento and American river investigations October 1995 through September 1996. Prepared for USFWS, Central Valley Anadromous Fish Restoration Program by CDFG, Environmental Services Division, Stream Flow And Habitat Evaluation Program, Sacramento, California.
- CDFG (California Department of Fish and Game). 1998a. Letter to James Smith, USFWS, from Richard Elliot, CDFG, on January 16, 1998. CDFG. On file at CDFG, Redding, California.
- CDFG (California Department of Fish and Game). 1998b. Report to the Fish and Game Commission: A status review of the spring-run chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento river drainage. Sacramento, California. Candidate Species Status Report 98-01.
- CDFG (California Department of Fish and Game). 1998c. Sacramento River winter-run chinook salmon annual report to the Fish and Game Commission. Inland Fisheries Division.
- CDFG (California Department of Fish and Game). 1998d. Memorandum to Battle Creek Files regarding habitat surveys on Ripley, Soap, and Baldwin Creeks.
- CDFG (California Department of Fish and Game). 1998e. California sport fishing regulations: Supplement No. 2. Publ. Sacramento Magazines Corp., Sacramento, California.
- CDFG (California Department of Fish and Game). 1998f. Memorandum concurring with USFWS position paper on Battle Creek watershed. On file at CDFG, Redding, California.
- CDFG (California Department of Fish and Game). No Date. Counts of steelhead at the fishway at Clough Dam on Mill Creek from 1953-54 to 1962-63. Prepared by F.W. Fisher. On file in CDFG, Region 1 Office, Redding, California.
- CDM (California Division of Mines). 1947. Shasta Main District. Cal. Journal of Mines and Geology. 43(2).
- CDM (California Division of Mines). N.d. California Geology. Bulletin 190.
- CDPW (California Department of Public Works). 1923. Flow in California Streams. Bulletin No. 5.
- CDWR (California Department of Water Resources). 1997. North Fork Battle Creek Eagle Canyon Diversion preliminary engineering fish passage project. California Department of Water Resources.
- CDWR (California Department of Water Resources). 1998. Reconnaissance level engineering investigation for fish passage facilities on Battle Creek. Memorandum Report, CDWR, Red Bluff, California.
- Chadwick-Darling, C. 1998. Presentation to the California/Nevada Chapter of the American Fisheries Society's 32nd Annual Conference, Sacramento, California, April 24, 1998.

- Coots, M. and T. Healey. 1966. Pacific Gas and Electric Company's Battle Creek System Power Project, Minor Part, License Number 1121. CDFG. 31pp.
- Doppelt, B., M. Scurlock, C. Frissell, and J. Karr. 1993. Entering the watershed: a new approach to save America's river ecosystems. Island Press, Washington, D.C.
- Erman, N.A. 1996. Status of aquatic invertebrates. Sierra Nevada Ecosystem Project: Final Report to Congress. Vol. II: Assessments and Scientific Basis for Management Options, Chapter 35. Wildland Resources Center Report No. 37. University of California, Davis, California.
- Evans, D. L. 1982. Status report on twelve raptors. U.S. Fish and Wildlife Service Special Report - Wildlife No. 238.
- FERC (Federal Energy Regulatory Commission). 1991. Environmental assessment for amendment of hydropower license: DeSabra-Centerville Project FERC Project No. 803-014, California. Federal Energy Regulatory Commission, Washington, D.C.
- FEMAT (Federal Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment. Report of the Forest Ecosystem Management Assessment Team. U.S. Government Printing Office 1993-197-071.
- Francis, R.C. 1993. Climate change and salmonid production in the North Pacific Ocean. *In*: Proceedings of the Ninth Annual Pacific Climate (PACLIM) Workshop, April 21-24, 1992, K.T. Redmond and V.L. Tharp [eds.]. Calif. Dept. of Water Res., Interagency Ecol. Stud. Prog., Tech. Rept. 34.
- Frissell, C.A., W.J. Liss, and D. Bayles. 1993. An integrated, biophysical strategy for ecological restoration of large watersheds. Pages 449-456 *in* D.F. Potts, editor. Proceedings of the symposium on changing roles in water resources management and policy. American Water Resources Association, Bellevue, Washington.
- Hallock, R.J. 1987. Sacramento River system salmon and steelhead problems and enhancement opportunities. California Advisory Committee on Salmon and Steelhead Trout. 92 pp.
- Hallock, R.J. 1989. Upper Sacramento River Steelhead. A Report to the US Fish and Wildlife Service.
- Hallock, R.J. and D.H. Fry. 1967. Five species of salmon, *Oncorhynchus*, in the Sacramento River, California. California Fish and Game 53:5-22.
- Hallock, R.J. and H. Rectenwald. 1990. Environmental factors contributing to the decline of the winter-run chinook salmon on the upper Sacramento River. *In*: Proc. 1990 Northeast Pacific Chinook and Coho Salmon Workshop. 141-145.
- Hallock, R.J., W.F. Van Woert, and L. Shapovalov. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout (*Salmo gairdnerii gairdnerii*) in the Sacramento River system. Fish Bulletin No. 114. California Department of Fish and Game, Sacramento, California.

- Hare, S.R. and R.C. Francis. 1993. Climate change and salmonid production in the North Pacific Ocean. Proceedings of the Int. Symp. on Climate Change and Northern Fish Populations, September 1992. Department of Fisheries and Oceans, Canada.
- Hart, J.L. 1988. Pacific fishes of Canada. Fisheries Research Board of Canada, Bulletin 180, Ottawa, Canada. 740 pp.
- Hasler, A.D. and A.T. Scholz. 1983. Olfactory imprinting and homing in salmon. Springer-Verlag, Berlin, 134 pp.
- Healey, M. 1993. Sacramento River chinook in perspective. *In: Notes and selected abstracts from the Workshop on Central Valley Chinook Salmon, Sponsored by Department of Wildlife and Fisheries Biology, University of California, Davis, January 4-5, 1993.*
- Hedgpeth, J.W. 1944. The passing of the salmon. *Scientific Monthly*. 59:370-378.
- Henjum, M.G., J.R. Karr, D.L. Bottom, D.A. Perry, J.C. Bednarz, S.G. Wright, S.A. Beckwitt, and E. Beckwitt. 1994. Interim protection for late-successional forests, fisheries, and watersheds: national forests east of the Cascade Crest, Oregon, and Washington. The Wildlife Society, Bethesda, Maryland.
- Hindar, K. 1992. Ecological and genetic studies on salmonid populations with emphasis on identifying causes for their variation. Ph.D. Thesis, University of Oslo, Oslo.
- Hollowed, A.B. and W.S. Wooster. 1991. Variability of winter ocean conditions and strong year classes of Northeast Pacific groundfish. ICES 1991/Variability Symp./Paper No. 33/Session 3.
- Hunt, W. G. 1987. Radio telemetry in the study of raptor habitat selection. *Raptor Research* 21(4):144-146.
- Hunter, M.A. 1992. Hydropower flow fluctuations and salmonids: a review of the biological effects, mechanical causes, and options for mitigation. Washington Department of Fisheries. Tech. Rept. No. 119. Olympia, Washington. 46 pp.
- Johnson, J.J. 1978. Yana. *In: Handbook of North American Indians, Vol. 8, California, Roperty F. Heizer, pp. 361-369. Washington: Smithsonian Institution.*
- KRBFTF (Klamath River Basin Fisheries Task Force). 1991. Long range plan for the Klamath River Basin Conservation Area Fishery Restoration Program. USFWS, Yreka, California.
- Magnuson, J.J. et al. 1990. Potential changes in the thermal habitat of Great Lakes and fish after global climate warming. *Transactions of American Fisheries Society* 119:254-264.
- Milner, A.M. and R.G. Bailey. 1989. Salmonid colonization of new streams in Glacier Bay National Park, Alaska. *Aquaculture and Fisheries Management*. 20, 179-192.
- MLTF (Mt. Lassen Trout Farm, Inc.). 1998. Visitor fact sheet. Mount Lassen Trout Farm, Red Bluff, California.

- Moyle, P.B. 1976a. Inland fishes of California. Univ. of California Press, Berkeley California. 405 pp.
- Moyle, P.B. 1976b. Fish introductions in California: history and impact on native fishes. *Biological Conservation*. 9:101-118.
- Moyle, P.B. 1993. Effects of temperature, flow and disturbance on adult spring-run chinook salmon. *In California Water Resources Center Report No. 79*. California Water Resources Center, UC Davis, Davis, California.
- Moyle, P.B. and G.M. Sato. 1991. On the design of preserves to protect native fishes. Pages 155-169 *in* W.L. Minckley and J.E. Deacon, editors. *Battle against extinction: native fish management in the American West*. University of Arizona Press, Tucson.
- Moyle, P.B. and J.J. Cech. 1988. *Fishes, an Introduction to Ichthyology*. Prentice Hall, Englewood Cliffs, NJ. 559.pp.
- Needham, P.R., H.A. Hanson, and L.P. Parker. 1943. "Supplementary report on investigations of fish-salvage problems in relation to Shasta Dam. *Spec. Sci. Rept. No. 26*. Fish and Wildlife Service.
- Needham, P.R., O.R. Smith, and H.A. Hanson. 1940. Salmon salvage problems in relation to Shasta Dam, California and notes on the biology of the Sacramento River salmon. *Transactions of the American Fisheries Society*, Toronto, Canada, September 5-6, 1940. Pp. 55-69.
- Nielsen, J.L., C. Carpanzano, M.C. Fountain, and C.A. Gan. 1997. Mitochondrial DNA and nuclear microsatellite diversity in hatchery and wild *Oncorhynchus mykiss* from freshwater habitats in Southern California. *Trans. Am. Fish. Society*. 126:397-417.
- NMFS (National Marine Fisheries Service). 1997a. Proposed recovery plan for the Sacramento River winter-run chinook salmon. NMFS, Long Beach, California.
- NMFS (National Marine Fisheries Service). 1997b. Proceedings of a workshop on the genetic effects of straying of non-native hatchery fish into natural populations. NOAA Tech. Memo. NMFS-NWFSC-30, NMFS, Seattle, Wa.
- NOAA (National Oceanographic Atmospheric Administration). 1994. Endangered and threatened species; status of Sacramento River winter-run chinook salmon. *Federal Register* 59:2(January 4, 1994):440-450.
- NOAA (National Oceanographic Atmospheric Administration). 1998. Endangered and Threatened Species: West Coast Chinook Salmon. *Federal Register* 63:45(March 9, 1998):11482-11520.
- Norris, L.A. and W.L. Webb. 1989. The effects of fire retardant on water quality. Pages 79-86 *In*: N.H. Berg, editor. *Proceedings of the symposium on fire and watershed management*. General Technical Report PSW-109. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

- NPS (National Park Service). circa 1998. The mountain reawakens: pamphlet describing the geology of Lassen Volcanic National Monument.
- ORCD (Okanogan Resource Conservation District). In preparation. Okanogan watershed management plan. Okanogan Resource Conservation District, Okanogan, Wa.
- Pascual, M.A. and T.P. Quinn. 1994. Geographical patterns of straying of fall chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), from Columbia River (USA) hatcheries. *Aquaculture and Fisheries Management*, 25(2): 12-30.
- PG&E (Pacific Gas and Electric). 1998a. Letter to Mike Ward, Terraqua Environmental Consulting, from Jean Oscamou, PG&E, concerning the history of Battle Creek fish ladders and screens. PG&E, Magalia, California. 3 pp.
- PG&E (Pacific Gas and Electric). 1998b. Letter to Mike Ward, Kier Associates, from Jean Oscamou, PG&E, providing comments on the review draft of the Battle Creek Salmon and Steelhead Restoration Plan, November 15, 1998. PG&E, Magalia, California. 3 pp.
- PG&E (Pacific Gas and Electric). 1999. A temperature model of Battle Creek based on models by Thomas R. Payne and Associates. Presented to the Battle Creek Working Group. on October 9, 1998
- TRPA (Thomas R. Payne and Associates). 1998d. A 1989 temperature model of upper Battle Creek, Al Smith Diversion to Eagle Canyon Diversion on North Fork Battle Creek and South Diversion to Inskip Powerhouse on South Fork Battle Creek:
- Power, T.M. 1996. Lost landscapes and failed economics: the search for a value of place. Island Press, Covelo, California.
- Quinn, T.P. 1984. Homing and straying in Pacific salmon. *In* J.D. McCleave, G.P. Arnold, J.J. Dodson, and W.H. Neill (eds.). *Mechanisms of migration in fishes*. Plenum Press, N.Y., N.Y.
- Quinn, T.P. 1997. Homing, straying and colonization. *In* Genetic effects of straying of non-native hatchery fish into natural populations. NOAA Tech. Memo. NMFS-NWFSC-30, NMFS, Seattle, Wa.
- Resources Agency of California, The. 1971a. Comments on the application for a new license of Battle Creek Project FPC No. 1121 to J. F. Roberts, PG&E, from Ford B. Ford, the Resources Agency of California, on February 9, 1971. On file in CDFG, Region 1 Office, Redding, California.
- Resources Agency of California, The. 1971b. Letter to G. M. Grant, Federal Power Commission, from N. B. Livermore, Jr., the Resources Agency of California, circa July 1, 1971. On file in CDFG, Region 1 Office, Redding, California.
- Reynolds, T. S. and C. Scott. no date. The Battle Creek Hydroelectric System and the North California Power Company 1900-1919. *Historic American Engineering Record*, California-2.

- Rieman, B., D. Lee, J. McIntyre, K. Overton, and R. Thurow. 1993. Consideration of extinction risks for salmonids. Fish Habitat Relationships Technical Bulletin Number 14, USDA Forest Service, Boise, Idaho.
- RMI (Resource Management Incorporated). 1998. Battle Creek Hydrologic/Economic Model. RMI, Sacramento, California.
- Rudzitis, G. 1996. People, ecosystems, and the changing American West. *Columbiana Magazine*, No. 19.
- Rutter, C. 1902. Natural history of the Quinnat Salmon. *Bulletin of the U.S. Fish Commission*. 22:65-141.
- Rutter, C. 1903. Natural history of the quinnat salmon: A report on investigations in the Sacramento River, 1896-1901: Extracted from U.S. Fish Commission Bulletin for 1902. Pages 86 to 131, Plates 10 to 18.
- Rutter, C. 1904. The fishes of the Sacramento-San Joaquin Basin, with a study of their distribution and variation. *Bull. of U.S. Bureau of Fisheries*. 27:103-152.
- SBFC (State Board of Fish Commissioners). 1896. Biennial Reports 1895-1896. State Board of Fish Commissioners. A.J Johnson, Superintendent State Printing, Sacramento.
- Schafter, R.G. 1980. Fish occurrence, size, and distribution in the Sacramento River near Hood, California during 1973 and 1974, CDFG, *Anad. Fish. Br. Rpt. No. 80-3*.

- Sverdrup (Sverdrup & Parcel and Associates, Inc.). 1986. An evaluation of alternative water supply systems for Coleman National Fish Hatchery. Prepared for: USFWS, Portland, Or.
- Sverdrup (Sverdrup & Parcel and Associates, Inc.). 1989. Advance project planning for water supply distribution, treatment and waste systems. For USFWS, Portland, Oregon.
- Tehama County. 1983. Application for license for construction and operation of South Fork Battle Creek Hydroelectric Project (Preliminary permit No. 5350). Report prepared for FERC by Tudor Engineering Company, San Francisco, California, and Environmental Science Associates, Inc. Novato, California, November 1983 for Tehama County Flood Control and Water Conservation District.
- TRPA (Thomas R. Payne and Associates). 1998a. A 1989 instream flow study: 1 of 8 components. Prepared for California Department of Fish and Game.
- TRPA (Thomas R. Payne and Associates). 1998b. A 1989 survey of barriers to the upstream migration of anadromous salmonids: 1 of 8 components. Prepared for California Department of Fish and Game.
- TRPA (Thomas R. Payne and Associates). 1998c. A 1989 temperature model of lower Battle Creek, Eagle Canyon and Coleman Diversions to Coleman Powerhouse: 1 of 8 components. Prepared for California Department of Fish and Game.
- TRPA (Thomas R. Payne and Associates). 1998d. A 1989 temperature model of upper Battle Creek, Al Smith Diversion to Eagle Canyon Diversion on North Fork Battle Creek and South Diversion to Inskip Powerhouse on South Fork Battle Creek: 1 of 8 components. Prepared for California Department of Fish and Game.
- TRPA (Thomas R. Payne and Associates). 1998e. Draft: A 1989 study of fish species abundance and distribution in Battle Creek: 1 of 8 components. Prepared for California Department of Fish and Game.
- Turner, J. 1997. Forum: Grizzly bear number 209. Wild Duck Review 3(1):11-13.
- U.S. Federal Power Commission. 1973. Pacific Gas and Electric Company, Project No. 1121: Order issuing license (major), accepting surrender of minor-part license, approving lease of project lands, and disposing of petitions to intervene. Federal Power Commission.
- USBR (U.S. Bureau of Reclamation). 1985. Coleman National Fish Hatchery and Keswick Fish Trap operations. U. S. Bureau of Reclamation, Sacramento, California.
- USBR (U.S. Bureau of Reclamation). 1991. Planning Report/Final Environmental Statement: Shasta outflow temperature control. U. S. Bureau of Reclamation, Sacramento, California. p VI-39.
- USBR (U.S. Bureau of Reclamation). 1996. Agreement for the purchase of water between the United States and Pacific Gas and Electric Company. U.S. Bureau of Reclamation Agreement No. 6-07-20-W1379

- USBR (U.S. Bureau of Reclamation). 1998a. Environmental assessment for temporary reduction in water diversions from Battle Creek. U.S. Bureau of Reclamation, Sacramento, California.
- USBR (U.S. Bureau of Reclamation). 1998b. Draft finding of no significant impact for temporary reduction in water diversions from Battle Creek. U.S. Bureau of Reclamation, Sacramento, California.
- USBR (U.S. Bureau of Reclamation). 1998c. Draft Battle Creek dam removals reconnaissance report. USBR, Technical Service Center, Denver, Colorado.
- USBSFW (U.S. Bureau of Sport Fisheries and Wildlife). 1962. A proposed development program for anadromous fish in California. Pacific Region, Portland, Or. 36 pp.
- USFS (U.S. Forest Service). 1992a. Lassen National Forest Land and Resource Management Plan. Lassen National Forest, Susanville, California.
- USFS (U.S. Forest Service). 1992b. Environmental Impact Statement for the Lassen National Forest Land and Resource Management Plan. Lassen National Forest, Susanville, California.
- USFS (U.S. Forest Service). 1997. Biological assessment of listed, proposed and petitioned threatened and endangered species of anadromous fish for : implementation of the Lassen National Forest Land and Resource Management Plan (as amended). Lassen National Forest, Susanville, California.
- USFS (U.S. Forest Service). 1998. Addendum to the September 1998 Biological assessment of listed, proposed and petitioned threatened and endangered species of anadromous fish for implementation of the Lassen National Forest Land and Resource Management Plan (as amended). Lassen National Forest, Susanville, California.
- USFS (U.S. Forest Service) and BLM (U.S. Bureau of Land Management). 1995. Environmental Assessment for the Interim Strategies for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH). USDA-Forest Service) and USDI-Bureau of Land Management.
- USFWS (U.S. Fish and Wildlife Service). 1940. An investigation of fish salvage problems in relation to Shasta Dam. USFWS Sci Rept. Fish No. 10. 200 pp.
- USFWS (U.S. Fish and Wildlife Service). 1949. The First Four Years of King Salmon Maintenance Below Shasta Dam, Sacramento River, California. *In: California Fish and Game Quarterly* Volume 35, No 2. 24pp.
- USFWS (U.S. Fish and Wildlife Service). 1957. Role of Coleman Hatchery in Maintaining a King Salmon Run. Research Report 47. 22pp.
- USFWS (U.S. Fish and Wildlife Service). 1958. The upper Sacramento River salmon and steelhead maintenance program, 1949 to 1956. USFWS Office Report. 96 pp.

- USFWS (U.S. Fish and Wildlife Service). 1963. Winter-run chinook salmon in the Sacramento River California with notes on water temperature requirements at spawning. USFWS Spec. Sci. Rept. 461, 9pp.
- USFWS (U.S. Fish and Wildlife Service). 1982a. Report of the USFWS on problem No. A-6 Coleman National Fish Hatchery and Keswick Fish Trap Central Valley Fish and Wildlife Management Study. May 1982. 75pp.
- USFWS (U.S. Fish and Wildlife Service). 1982b. Fish hatchery management. Washington, D.C. 480 pp.
- USFWS (U.S. Fish and Wildlife Service). 1984. Evaluation report of the potential impacts of the proposed Lake Red Bluff water power project on the fishery resources of the Sacramento River. U. S. Fish and Wildlife Service, Division of Ecological Services, Sacramento, California. 89 pp (plus appendices).
- USFWS (U.S. Fish and Wildlife Service). 1986a. Pacific Bald Eagle Recovery Plan. Portland, Oregon.
- USFWS (U.S. Fish and Wildlife Service). 1986b. Correspondence from J. McKeivt to D. Dixon Collins, Elektra Power Corporation, Palo Alto, California. Dated 23 January 1986. *In*: Elektra Power Corporation. 1986. Response to deficiencies in application for license for North Fork Battle Creek Project, Shasta County, California (FERC #8725). Filed before the Federal Energy Regulatory Commission, January 1986 by Elektra Power Corporation, Palo Alto, California.
- USFWS (U.S. Fish and Wildlife Service). 1987a. An analysis of the effectiveness of the mitigation plan for Shasta and Keswick Dams. 36pp.
- USFWS (U.S. Fish and Wildlife Service). 1987b. Coleman National Fish Hatchery station development plan. U. S. Fish and Wildlife Service, Region One.
- USFWS (U.S. Fish And Wildlife Service). 1988. Letter to W.D. Pahland, Pacific Gas and Electric, from J.J. McKeivt, March 22, 1988. USFWS.
- USFWS (U.S. Fish and Wildlife Service). 1990. Memorandum to Jerry Grover, Association Manager, from J. Scott Foott, USFWS: Fall chinook adult passage above Coleman NFH, February 22, 1990. USFWS, Anderson, California.
- USFWS (U.S. Fish and Wildlife Service). 1992. Use of growth data to determine the spatial and temporal distribution of four runs of juvenile chinook salmon in the Sacramento River California. 17pp.
- USFWS (U.S. Fish and Wildlife Service). 1993. Biological assessment on the effects of Coleman National Fish Hatchery operations on winter-run chinook salmon.
- USFWS (U.S. Fish And Wildlife Service). 1994. Action plan for fishery resources and aquatic ecosystems. USFWS.

- USFWS (U.S. Fish and Wildlife Service). 1995a. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volumes 1-3. May 9, 1995. Prepared by the U.S. Fish and Wildlife Service under direction of the Anadromous Fish Restoration Core Group. Stockton, California.
- USFWS (U.S. Fish and Wildlife Service). 1995b. Report of escapement of hatchery origin winter chinook salmon to the Sacramento River in 1995. As included in Application for a Permit to Enhance Propagation Survival of Endangered or Threatened Species Under the Endangered Species Act - Coleman National Fish Hatchery Winter Chinook Salmon Propagation Program 1995.
- USFWS (U.S. Fish and Wildlife Service). 1996a. Escapement of hatchery-origin winter chinook salmon (*Oncorhynchus tshawytscha*) to the Sacramento River in 1995, with notes on spring chinook salmon in Battle Creek. USFWS Report. U.S. Fish and Wildlife Service, Northern Central Valley Fish and Wildlife Office, Red Bluff, California.
- USFWS (U.S. Fish and Wildlife Service). 1996b. Draft temperature suitability criteria for three species of salmon: Trinity River. USFWS, Arcata, California.
- USFWS (U.S. Fish and Wildlife Service). 1996c. FY96 Investigational Report: Health and physiology monitoring of Coleman NFH fall-run chinook smolts (FCS-BCW-95-COL), Component of 1996 marked out-migrant study. USFWS, Anderson, California.
- USFWS (U.S. Fish and Wildlife Service). 1997a. Draft. Escapement of spring chinook salmon (*Oncorhynchus tshawytscha*) to Battle Creek, California in 1996. USFWS Report. U.S. Fish and Wildlife Service, Northern Central Valley Fish and Wildlife Office, Red Bluff, California.
- USFWS (U.S. Fish and Wildlife Service). 1997b. Draft. Evaluation of the Sacramento River winter chinook salmon (*Oncorhynchus tshawytscha*) propagation program in 1996. USFWS Report. U.S. Fish and Wildlife Service, Northern Central Valley Fish and Wildlife Office, Red Bluff, California.
- USFWS (U.S. Fish and Wildlife Service). 1997c. Revised draft restoration plan for the anadromous fish restoration program: a plan to increase natural production of anadromous fish in the Central Valley of California. Prepared by USFWS and the Anadromous Fish Restoration Program Core Group. Sacramento, California.
- USFWS (U.S. Fish and Wildlife Service). 1997d. Water treatment system cost study and alternatives analysis. USFWS, Sacramento, California.
- USFWS (U.S. Fish and Wildlife Service). 1997e. Coleman Fish Hatchery improvements environmental assessment. USFWS, Sacramento, California.
- USFWS (U.S. Fish and Wildlife Service). 1997f. Letter to Michael Black from James G. Smith, USFWS, regarding Mr. Black's historical analysis of Coleman National Fish Hatchery, December 11, 1997. USFWS, Red Bluff, California.

- USFWS (U.S. Fish and Wildlife Service). 1997g. Letter to Randall Benthin, CDFG, from James G. Smith, USFWS: Protocol for fish trapping at Coleman National Fish Hatchery's barrier dam on Battle Creek. USFWS, Red Bluff, California.
- USFWS (U.S. Fish and Wildlife Service). 1997h. Letter prepared by Wayne S. White (Field Supervisor). May 8, 1997. Subject: Pit 3, 4, and 5 Project, FERC No. 233 Preliminary Analysis of Bald Eagle and Fishery Studies.
- USFWS (U.S. Fish and Wildlife Service). 1998a. Supplemental Fish and Wildlife Coordination Act report – Red Bluff Diversion Dam and the Tehama-Colusa Canal. Sacramento, California.
- USFWS (U.S. Fish and Wildlife Service). 1998b. Draft CNFH barrier trap summary presented to the Battle Creek Working Group, 1998. USFWS, Red Bluff, California.
- USFWS (U.S. Fish And Wildlife Service). 1998c. Letter from Wayne White, USFWS, February 25, 1998. U.S. Fish And Wildlife Service, Sacramento, California.
- USFWS (U.S. Fish And Wildlife Service). 1998d. May 1998 status of key Fish and Wildlife Service activities in the Battle Creek watershed. USFWS, Red Bluff, California. 2 pp.
- USFWS (U.S. Fish And Wildlife Service). 1998e. Letter to Richard Elliot, CDFG, from Scott Foott, James Smith, and Tom Nelson, USFWS, expressing support for the restoration of Battle Creek, on January 9, 1998. USFWS, Red Bluff, Ca
- USFWS (U.S. Fish and Wildlife Service). 1998f. USFWS position paper on the Battle Creek watershed. USFWS , Sacramento, California. April 3, 1998.
- USFWS (U.S. Fish and Wildlife Service). n.d.. Draft: Site and interpretive development for Coleman National Fish Hatchery and Battle Creek Wildlife Area. USFWS Red Bluff, California.
- USGS (United States Geological Survey). 1956. Manton Quadrangle Map.
- USGS (United States Geological Survey). 1995. Water Resources Data California: Water Year 1994. USGS Water-Data Report CA-94-4
- USFRHAC (Upper Sacramento River Fisheries and Riparian Habitat Advisory Council). 1989. Upper Sacramento River fisheries and riparian habitat management plan. State of California Resources Area. 158 p.
- Utter, F.M. 1991. Biochemical genetics and fishery management: an historical perspective. *Journal of Fish Biology*. 39(supplement A):1-10.
- Vogel, D.A. and K.R. Marine. 1991. Guide to upper Sacramento River chinook salmon life history. Prepared for U.S. Bureau of Reclamation by CH2MHill.
- Waples, R.S. 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest. *Can. J. Fish. Aquat. Sci.* 48:124-133.

- Ward, M. B. 1988. Adult steelhead trout utilization of summer holding pools, Middle Fork Eel River, California. *In: Proc. 1988 Conf. West. Div. Am. Fish. Soc.*, July 10-13, 1988.
- Ward, M.B. 1993. The physical dynamics of the Subarctic Front of the North Pacific Ocean and its relation to salmon (*Oncorhynchus* spp.) production. M.S. Thesis, University of Washington, Seattle, Wa. 113 pp.
- Wissmar, R.C., J.E. Smith, B.A. McIntosh, W.L. Hiram, G.H. Reeves, and J.R. Sedel. 1994. Ecological health of river basins in forested regions of eastern Washington and Oregon. General Technical Report PNW-GTR-326. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.
- Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley drainage of California. *In: Sierra Nevada Ecosystem Project Final report to Congress, vol. III, Assessments, Commissioned Reports, and Background Information.* Univ. California, Davis, California., Centers for Water and Wildland Resources. pp. 309-361.
- Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical abundance and decline of chinook salmon in the Central Valley region of California. *North American Journal of Fisheries Management.* 18:487-521.

APPENDIX A. HISTORY OF THE BATTLE CREEK WORKING GROUP.

The Battle Creek Working Group (BCWG) was convened in February 1997 by stakeholders frustrated with the lack of progress on Battle Creek restoration activities. The BCWG includes stakeholder representatives from the State and federal resource agencies, and fishery, environmental, local, agricultural, power, and urban stakeholder communities. The BCWG has been a successful forum for:

- briefings and discussions on the many ongoing Battle Creek programs and their coordination;
- providing the opportunity to urge the development of a comprehensive restoration plan that will give a “big picture” context for all of these activities;
- developing strategies to address problems and develop a stakeholder support base for the timely and efficient restoration of Battle Creek’s outstanding fishery resources; and
- creating a broad based stakeholder support group for the locally-convened Battle Creek Watershed Conservancy, in part, to assure that the involved federal and State agencies are sensitive to and responsive to local community concerns and issues.

To date, approximately 80 people have attended 14 BCWG meetings held since February 1997. In addition, many of these individuals and others have attended meetings of the BCWG subcommittees which include: The Environmental Compliance and Permitting Subcommittee, Biological Team, Hydropower Subcommittee, and Coleman National Fish Hatchery Historical Production Subcommittee.

The BCWG has worked successfully on several issues including resolution of Coleman National Fish Hatchery (CNFH) water quality concerns, the history of CNFH mitigation, and the siting of an appropriate winter-run chinook salmon rearing facility. In addition, the BCWG serves as the Technical Advisory Committee for The Battle Creek Salmon and Steelhead Restoration Plan being prepared by Kier Associates. This Plan will serve as the technical foundation for negotiations for a comprehensive restoration plan that will occur between Pacific Gas and Electric Company, California Department of Fish and Game, US Bureau of Reclamation, US Fish and Wildlife Service, and National Marine Fisheries Service.

Listed below is a timeline of key dates associated with the evolution of the BCWG. For each date, a description is provided of items addressed by the BCWG. Following the timeline is a matrix listing meeting attendees and affiliations.

BATTLE CREEK WORKING GROUP TIMELINE²⁴

1/28/97 - Conference call convened by Jason Peltier, CVPWA, to discuss the idea of forming a Working Group on Battle Creek Restoration.

2/3/97 - BCWG Meeting # 1, Sacramento - Discussed BCWG membership, goals, tasks, etc. and planning initiatives affecting Battle Creek.

2/6/97 - Jason Peltier memo to interested parties explaining the purposes of the BCWG and soliciting participation.

3/11/97 - BCWG Meeting #2, Sacramento - Discussed BCWG purposes and goals, PG&E slide presentation on fishery resources above CNFH, USFWS presentation on their Battle Creek activities, MWDC presentation on Category III expenditures on Battle Creek, and BCWG operations and mechanics.

4/15/97 - BCWG Meeting #3, Chico –

5/13/97 - BCWG Meeting #4, - Discussed formation of the BCWC, CNFH mitigation obligation, status of CNFH ozone and related environmental documentation, CNFH risk assessment, status of Battle Creek technical plan development.

6/19/97 - Battle Creek CNFH Historical Production Subcommittee Meeting # 1 - Discussed CNFH's history and commissioned Michael Black to draft a report.

6/30/97 - BCWG Meeting # 4, Willows - Discussed scopes of work for both the Battle Creek conservancy and the technical plan efforts, CNFH historical production subcommittee report, CNFH final ozone EA, CNFH 5-7 year CNFH evaluation plan, and the proposed Buckhorn hatchery.

8/7/97 - Battle Creek CNFH Historical Production Subcommittee Meeting # 2 - Discussed findings in Michael Black's report on CNFH's institutional situation as it related to Shasta-Keswick CVP salmon mitigation (1939-1952) responsibilities and beyond (1952-1992).

8/19/97 - BCWG Meeting # 5, Red Bluff - It was agreed that the BCWG would serve as the Technical Advisory Committee for the technical plan. Discussed progress being made by the Historical Production Subcommittee, CNFH evaluation, convening of the Battle Creek Watershed Conservancy, and Winter-Run Rearing Facility MOU.

9/26/97 - BCWG Meeting # 6, Red Bluff – Discussed USFWS CNFH activities, progress being made by the Historical Production Subcommittee, Battle Creek trout hatcheries, status of the winter-run hatchery, Tom Payne IFIM Report, and BCWC activities.

11/18/97 - BCWG Meeting # 7, Red Bluff - Discussed interim agreement between PG&E and USBR for payment of foregone power, Tom Payne IFIM Report, CNFH historical review report, CNFH reevaluation, USFWS Battle Creek activities, status of the Shasta winter-run rearing facility, and BCWC activities.

1/9/98 - BCWG Meeting # 8, Red Bluff - Discussed “strawman” restoration proposal, Tom Payne IFIM report, BCWC update, CNFH, USFWS' comments on Michael Black's Historical Review of CNFH, relationship of USFWS planning efforts (e.g., re-evaluation study) to Battle

²⁴ This list includes selected actions undertaken during BCWG meetings. It does not include subcommittee meetings. See Appendix Table 1 for lists of participants at meetings with sign-up sheets.

Creek restoration, extension of comment period for USFWS scoping process/re-evaluation process, status of environmental assessment for increased Battle Creek flows, and CALFED future funding opportunities.

3/4/98 - BCWG Meeting # 9, Redding - Discussed comments CDFG received regarding the strawman restoration proposal, USFWS “Battle Creek Position Paper,” PG&E’s divestiture process, USBR interim water acquisition, CDWR’s Eagle Canyon Diversion Dam Screen and Ladder Report, USFWS Battle Creek actions, Technical Plan/Community Plan Integration, Battle Creek Salmon and Steelhead Technical Plan, Battle Creek Watershed Community Plan, BCWC update, and BLM update.

4/21/98 - BCWG Meeting # 10, Red Bluff - Discussed revised USFWS Battle Creek Position Paper, USFWS Battle Creek Activities, BCWC’s Pending Annual Meeting, USBR’s Draft EA for interim flows, USFWS’s hatchery reevaluation process, USFWS monitoring at CNFH barrier dam, CDWR’s Category III Fish Passage Study, CNFH intake improvements, Livingston Stone Winter-Run Rearing Facility, Battle Creek hydropower evaluations, BCWC update, Battle Creek Technical Plan update, NMFS ESA update, CDFG regulations update, and the convening of a Biological Team to develop flow recommendations.

5/27/98 - BCWG Meeting # 11, Red Bluff - Discussed 5/13 meeting between stakeholders and PG&E management, convening of a regulatory compliance subcommittee, Battle Creek technical plan update, Biological Subcommittee Report, USFWS Battle Creek restoration activities, NMFS ESA update, CDFG fisheries regulations, BCWC update, Lassen National Forest activities, and CALFED’s Comprehensive Monitoring Assessment and Research Program (CMARP).

7/7/98 - BCWG Meeting # 12, Red Bluff – USFWS and PG&E discuss June meeting between PG&E and resource agencies and confirm a commitment to complete a restoration proposal by September 30, Regulatory Compliance Committee reported first meeting, Kier Assoc. reported Biological Team progress, other agencies gave brief updates on activities.

8/26/98 - BCWG Meeting # 13, Red Bluff – Kier Assoc. and PG&E present completed biologically-optimum flow results, BCWC presents concerns about upper Battle Creek watershed and the possible need for meadow restoration.

9/17/98 - BCWG Meeting # 14, Chico – Draft Restoration Plan presented to BCWG, DWR and USBR presented draft reports on potential facilities modifications at PG&E facilities to accommodate fisheries restoration, RMI and PG&E presented economic models for potential restored flow regimes, other agencies gave brief updates on activities.

11/6/98 - BCWG Meeting #15, Red Bluff – PG&E reported on progress to develop MOU and discussed results of 9/23/98 and 10/28/98 negotiations between PG&E and resource agencies, USFWS gave in-depth review of history and function of CNFH barrier weir, other agencies gave brief updates on activities.

12/17/98 - BCWG Meeting #16, Anderson – Discussed 12/10/98 negotiations between resource agencies and PG&E, evaluated progress of Restoration Plan and suggested ways to capture comments on draft Plan, USBR reported that have final costs for dam decommissioning and other proposed facility modifications, BLM presented land acquisition plans and heard much negative feedback, BCWC presented detailed rebuttals to BLM’s plans,

Appendix Table 1. List of participants in BCWG meetings. Refer to Table 1 for acronyms.

Name	Affiliation	Feb '97	Mar '97	Apr '97	May '97	Jun '97	Aug '97	Sep '97	Nov '97	Jan '98	Mar '98	Apr '98	May '98	Jul '98	Aug '98
Laurie Aumack	WSRCD			X	X		X	X		X	X	X	X	X	X
Richard Bauman	WSRCD									X					
Frances Berg	BLM									X	X	X		X	
Nat Bingham	PCFFA	X	X	X	X		X	X	X	X	X				
Serge Birk	CVPWA	X	X	X	X			X	X	X	X	X	X	X	X
Michael Bogue	NCAL GUIDES									X					
Jim Buell	MWDSC									X					
Brad Carter	LASSEN TROUT							X							
Susan Chapelle	USFS												X		
Stina DeAtley	?										X				
Teresa DeBono	PG&E														X
Jennifer Decker	CDFG									X					
Chuck DeJournette	TFF									X					
Kevin Dossey	CDWR											X			
Nannette Englebrite	WAPA		X					X		X					
Ron Fehringer	CH2M HILL			X	X										
Scott Ferris	NCAL GUIDES									X					
Dan Free	USFWS		X	X	X	X		X	X	X	X		X		X
Mark Gard	USFWS											X			
Gene Geary	PG&E											X			
Ian Gilroy	NMFS				X			X	X	X		X	X	X	X
Kayl Glyn Echols	CDWR			X	X										
David Gore	USBR									X					
Roger Guinee	USFWS		X	X											
Scott Hamelberg	USFWS						X								
Patrick Higgins	KIER ASSOC.														X
Steve Hirsch	MWDSC/FWS	X	X	X	X		X		X	X	X	X	X	X	X
Buford Holt	USBR			X	X			X		X	X	X	X		X

Appendix Table 1 continued. List of participants in BCWG meetings. Refer to Table 1 for acronyms.

Name	Affiliation	Feb '97	Mar '97	Apr '97	May '97	Jun '97	Aug '97	Sep '97	Nov '97	Jan '98	Mar '98	Apr '98	May '98	Jul '98	Aug '98
Jeff Souza	WSRCD			X	X					X	X			X	
Curtis Steitz	PG&E										X	X			
Brian Stewart	CDWR									X	X			X	X
Mark Stopher	CDFG														X
Van Tenney	GCID			X											
Audrey Tennis	C.W.C.			X	X										
Kim True	USFWS									X				X	
Steve Turek	CDFG												X		
Mike Ward	KIER ASSOC.										X	X	X	X	X
Phil Warner	CDFG									X					
Bernie White	TCRCD										X				

APPENDIX B. RESPONSES TO WRITTEN COMMENTS TO THE DRAFT RESTORATION PLAN.

Continuous sharing of information among the BCWG during the development of this Restoration Plan helped insure that the final review draft was a collaborative effort. The BCWG further decided that all written comments on the final review draft of this Restoration Plan, and the authors' responses, would be included in the final Restoration Plan. Written comments were received from BCWP, BCWG, PG&E, and NMFS. Verbal comments on the draft were received from CDFG, USFWS, MWDSC, and others.

Comments from the BCWP via email

November 29, 1998

To: Mike Ward
From: Laurie Aumack
Re: Comments on Draft Battle Creek Report

You indicated you wanted to receive any comments about text, so here are corrections.

Page 2, next to last line of footnote - delete "is and a series of boulder-clusters"

Action Taken: Text modified as suggested.

Page 9, to be consistent with previous page paragraph 4, line 4, "hatchery origin winter-run" should read "hatchery-run winter-run"

Action Taken: Text modified as suggested.

Page 10, paragraph 2 line 3, list of numbers need semi colons instead of comas to read accurately.

Action Taken: Text modified as suggested.

Page 14, line 2 *Oncorhynchus mykiss* needs to be in italics

Action Taken: Text modified as suggested.

Page 19, paragraph 2, "Mt. Lassen Trout Farms, Inc" is the correct reference for the trout farm business

Action Taken: Text modified as suggested.

Page 20, paragraph 1 and 2 use weir and dam when referring to barrier, could you use one or the other?

Action Taken: Text modified as suggested.

Page 22, paragraph 2, seems there should be a specific citing to back up CDFG notification to PG&E that screening of the hydro canal intakes was unnecessary around 1970. (The inference is that CDFG was unaware at the

Appendix B. Responses to written comments to the draft restoration plan.

time as to the need for screening or that would seem to be the interpretation, particularly by the public who may read this.)

Action Taken: These issues were addressed by further citation and by more explanation. See changes to this paragraph and additional paragraph in same section. It looks like CDFG was balancing a popular sport fishery with the need to screen for anadromous fish – a cultural oddity, perhaps, from contemporary perspectives.

Page 22, paragraph 5, could you add "triploids" perhaps in parenthesis to the reference of "One fishing resort stocks 400 sterile (triploid) rainbow trout...."

Action Taken: Text modified as suggested.

Page 23, paragraph 3, line 3 delete "in" just prior to "after October 1 when...."

Action Taken: Text modified as suggested.

Page 23, paragraph 4 line 3 and line 5, Macumber Reservoir, is spelled McCumber Reservoir, (I did not notice other locations with errors, however I did not check specifically for the spelling of McCumber).

Action Taken: "Macumber" is used most frequently in published references.

Also regarding the reference to McCumber, don't the concerns of non-game fish also apply to North Battle Creek Reservoir .

Action Taken: Perhaps, but I found no specific documentation to that effect.

Page 27 Table 6 Suggestion for clarification add: Battle Creek Watershed Project (created by an MOU between Tehama County Resource Conservation District and Western Shasta Resource Conservation District) and either delete the two separate listings or to be most accurate list all BCWP, TCRC and WSRCD.

Action Taken: Text modified as suggested.

Also, please change to Mt. Lassen Trout Farms, Inc. (MLTF) not Lassen Trout Farms (LTF)

Action Taken: Text modified as suggested.

Page 29, paragraph 2, line 3 "The Tehama and Shasta....." , should read "The Tehama County Resource Conservation District (TCRC) and the Western Shasta Resource Conservation District (WSRCD) received a 1996....."

Action Taken: Text modified as suggested.

Page 29, paragraph 3 line 4, could better reflect interests of the BCWC by reading as follows "....discuss other matters of concern to local landowners, including education, upper watershed processes, solid waste management,"

Action Taken: Text modified as suggested.

Page 30, last paragraph, line 1 elaborate should be "elaborated"

Action Taken: Text modified as suggested.

Battle Creek Salmon and Steelhead Restoration Plan

Page 33, section on Stream-Dependent Economic Values, line 11, a should/would issue. From the perspective of the landowners they would prefer it to read "would not impact existing agriculture." Is that possible to change? I am reading it from their standpoint and the do want assurances.

Action Taken: Text modified as suggested.

Page 35, paragraph 4. The headwaters of Battle Creek and it's tributaries are not all on LNF, part originate in Lassen National Volcanic Park and on private lands. Suggestion for this section: "The headwaters of Battle Creek are predominately on public lands with the majority originating on Lassen National Forest (LNF) or Lassen National Volcanic Park (LNVP)."

Action Taken: Text modified as suggested.

Page 36 note:.... Regarding LNF, "well upstream of available anadromous habitat and downstream water users appear to play a key role in the restoration", Paragraph 3, lines 4-8. Understanding that the information is from the Forest Service, is there any way to add that the BCWC is concerned that about the stewardship of the entire watershed. Somehow roads appear at this time to perhaps have an impact, due to possible erosion. There is concern about the contribution of sediment and general road conditions throughout the watershed. Can you add a statement to this effect? This would be consistent with the Goal of the Conservancy "To preserve the environmental and economic resources of the Battle Creek watershed through responsible stewardship, liaison, cooperation and education."

Action Taken: The discrepancies that you point out in this section have been addressed by the addition of a new paragraph citing Section 7 consultation between NMFS and USFS.

Page 37, paragraph 2, reference to the ranch should read "Battle Creek Meadows Ranch"

Action Taken: Text modified as suggested.

Page 75, paragraph 1, line 1 "CDFW (1997, 1998)" seems to not fit the list of literature cited on pages 88 - 101. Is this reference supposed to be California Department of Water Resources (CDWR)?

Action Taken: Yes, text modified as suggested.

Thank you for your consideration of these corrections.

Laurie Aumack

Comments from PG&E

Mike Ward
Kier Associates
P.O. Box 85
2360 Highway 20
Wauconda, WA 98859

December 14, 1998

Jean R. Oscamou
Pacific Gas and Electric Company
Hydro Generation
15449 Humbug Road
Magalia, CA 95954

Dear Jean,

Thank you for the in-depth comments on the draft Battle Creek Salmon and Steelhead Restoration Plan. Your comments, as well as detailed responses from BCWC, USFWS, CDFG, and NMFS, have helped improve this document. As we learned at the last BCWG meeting, your comments and our response will be published in the final Restoration Plan.

I would like to share with you my response to your comments before I publish the final draft. The vast majority of your comments were noted and incorporated directly into the Restoration Plan. However, a few were either 1) incorporated in-part, due to differing interpretations than those offered by your reviewers, or 2) were contradicted by other suggested changes and were omitted. I provide you point-by-point details of how I addressed your comments. My goal is to satisfy your concerns wherever possible. If you have any further misgivings concerning my suggested changes or "leave as is" text, please contact me at your earliest convenience.

Point-by-Point Response to Comments

PG&E COMMENT: The scope and technical detail of the draft are quite extensive. Perhaps some judicious editing could condense and organize the document to make it a bit easier to read for a wider audience.

Action Taken: Acknowledge and edited.

Where an organization's name appears for the first time, follow it with an abbreviation in parentheses and use the abbreviation from that point forward in the document. Also, be consistent with the organization name and abbreviation. As an example, the Calif. Dept. of Fish and Game is referred to in three different ways on page one. Moving Table 6 to a point near the front of the document would also provide the reader with references more readily.

Action Taken: Nomenclature consistency confirmed. Table 6 moved up. Names will be cited once and then the acronym then on, though full names will be repeated the first time they appear in the text even if the acronym was introduced in the Exec. Summary.

Consistent nomenclature needs to be applied throughout. The creek branches are North Battle Creek and South Battle Creek. They are referred to in this manner and also as North Fork and South Fork Battle Creek. The latter terminologies should be corrected wherever they appear.

Action Taken: Nomenclature consistency confirmed. USGS topographical maps say “North Fork of Battle Creek” – I revised all to be “North Fork Battle Creek” or “South Fork Battle Creek”, unless I’m referring to the “forks” as in “the anadromous reaches of the North and South forks of Battle Creek” where I use the “of.”

Another misnomer applies to North Battle Creek Feeder facilities. They are sometimes referred to as simply North Battle Feeder. For consistency and correct reference, the former terminology should be applied throughout the document.

Action Taken: Incorporated as suggested.

We find the subtle references to Eagle Canyon throughout the document highly objectionable. As you are keenly aware, we are involved in negotiating a comprehensive plan with the resource agencies that involves an array of actions, including some proposed for Eagle Canyon. The use of this document as a de facto lobbying tool for removal of Eagle Canyon diversion is extremely objectionable to us and has the effect of souring the negotiation atmosphere. Comments later in this letter will address those instances specifically.

Action Taken: Modified many references throughout the document while realizing that the habitat in Eagle Canyon is widely viewed by many Restoration Plan readers as habitat that characterizes some of the most unique properties of this watershed. Some references to Eagle Canyon were suggested by other reviewers.

Adverse effects of measures to reduce straying via separation of South and Inskip powerhouse outflows from South Battle Creek waters are glossed over or ignored. The facts are that the reaches of South Battle Creek identified as winter run and spring run habitat will have water temperatures too high for egg incubation and adult holding habitat beginning in June for a typical water year and average meteorological conditions. Specific detailed comments on treatment of thermal modeling in the draft are provided in the following section.

Action Taken: Addressed with new text in Technical Plan – see specific changes pertaining to your specific comments below.

Specific Comments

Cover Photo - A more generic photograph of North Battle Creek or of the anadromous species that the plan addresses would be more appropriate. Focus on Eagle Canyon is an irritant, as noted above.

Action Taken: Will use the same photograph but with a more generalized caption. This picture shows off a pleasant looking feature of the watershed that is distinctive; it looks like nowhere else in the Central Valley.

Cover Photo Caption - The hyperbole describing Eagle Canyon is out of place. We have identified potentially excellent habitat for salmon and steelhead in several reaches of the Battle Creek system. A toned-down

Appendix B. Responses to written comments to the draft restoration plan.

Table of Contents - The "Introduction" should be changed to "Background and History"; it is much more than an introduction. At the end of the "Introduction" there is a section entitled "Goals of Battle Creek Salmon and Steelhead Restoration.". This section should be moved. It could be a stand alone section or included in the beginning of the Technical Plan section.

Action Taken: "Introduction" changed to "Foundation for Restoration" in response to many comments and to acknowledge that information previously in the Intro. is fundamentally important to the new analyses presented in the Tech. Plan.

Executive Summary - None is provided, but this lengthy and technical document fairly screams out for such an addition to set the stage for the reader prior to embarking on the journey through the body of the plan.

Action Taken: An executive summary is now provided.

Pg. 1, para. 2 - The first sentence would lead one to think there were never salmon and steelhead anywhere else, which is not the case. The Sacramento and its many tributaries in the area, used as references later in the report, all supported these fisheries to various extents. Battle Creek needs to be put into perspective with the whole upper Sacramento system.

Action Taken: Text modified as suggested.

Pg. 1, para. 5 - The sentence makes the first mention of the "Battle Creek Salmon and Steelhead Restoration Plan", which is later abbreviated "Restoration Plan" throughout the document. The sentence should read, "This Battle Creek Salmon and Steelhead Restoration Plan (Restoration Plan)" Then wherever else the Restoration Plan is referenced in the document it should be capitalized. It currently is not.

Action Taken: Text modified as suggested.

Battle Creek Schematic Diagram - Several corrections are required here. The photo of South Powerhouse is incorrectly titled "South Fork Battle Creek Powerhouse"; Lakes Grace and Nora are incorrectly titled "Grace Reservoir" and "Nora Reservoir"; Darrah Springs Hatchery is incorrectly titled "Darrah Hatchery"; the new additions of Asbury Diversion Dam, Lower Ripley Creek Feeder, Upper Ripley Creek Feeder, and Soap Creek Feeder all need to be repositioned upstream of their respective receiving waterways rather than downstream as now depicted.

Action Taken: Text modified as suggested.

Pg. 6, para. 3 - This paragraph makes mention of problems associated with genetic characterization of Sacramento chinook and the hatchery caused hybridization of spring- and fall-run chinook in the Feather River and possibly by early attempts to propagate spring-run in Battle Creek. The plan should also note that the completion of Shasta Dam has also caused hybridization of mainstem spring- and fall-run chinooks (a potential source of spawners in Battle Creek) and that hatchery produced spring-run from the Feather River Hatchery are also known to enter Battle Creek.

Action Taken: Information from page V-16 of CDFG 1998 (spring-run report) is now included to support the observations that you mention.

On page 10, paragraph 2, the plan further states that some Battle Creek spring-run are known to over-summer in large pools in the Sacramento and then ascend into the creek just prior to spawning. If this is true, the

interbreeding of Battle Creek spring- and fall-run chinooks may have occurred as a result of Coleman hatchery operations.

Action Taken: Text dealing with genetics is modified on page 6 to address this concern (see above).

Appendix B. Responses to written comments to the draft restoration plan.

North Battle Creek and the Inskip reach (prior to the closure of Coleman Fish Ladder) of South Battle Creek. PG&E believes that this information is noteworthy and that this paragraph should document the numbers and distribution of salmon released upstream during this period.

Action Taken: Text added to "Fall-Run Chinook Salmon" section and reads as follows: "Access by fall-run chinook salmon to the Battle Creek watershed upstream of CNFH has historically been restricted by operation of the CNFH barrier dam to collect broodstock. However, during the period from 1985 to 1989, fall-run were intentionally allowed passage over the barrier dam. During an aerial survey in 1985, fall-run chinook were observed in the Wildcat, Coleman, and Inskip reaches, in numbers decreasing with distance upstream (Dave Hoopaugh, retired CDFG, pers. comm.). From 1986 to 1989, fall-run were intentionally confined downstream of Wildcat and Coleman dams by the closure of fish ladders at these dams." Actual dates are being verified.

Pg. 14, para. 2 - Identify the hydropower reservoirs by name referred to in the last sentence.

Action Taken: Text modified as suggested.

Pg. 14, footnote 6 - during fish population studies conducted by TRPA in 1989, Wildcat Diversion (not Eagle Canyon) was closed prevent chinook salmon migration above this point.

Action Taken: Text modified as suggested.

The footnote is not clear regarding whether the observations were in 1989 or 1998.

Action Taken: Text modified as suggested.

Also, the footnote should include the explanation that the ladders were closed at the request of resource agencies (see page 21, paragraphs 3 and 4).

Action Taken: Text modified as suggested.

Pg. 15, para. 3 - The use of Eagle Canyon as a reference point is arbitrary and a poor choice. A better reference would be the confluence of North and South Battle Creeks as it is a single point central in the system, not a geographic feature that stretches over nearly three miles, and can readily be identified by readers less familiar with the watershed.

Action Taken: Text modified to read "within approximately ten air miles of the foothills reaches of the North and South forks of Battle Creek."

Pg. 15, para. 4 - As previously communicated, comparing Battle Creek to the Pit River situation is at best a great stretch. The terrain, river features, and fisheries are markedly different. The main prey species of the eagles in the Pit River area are squawfish and suckers. There are also rainbow and brown trout present, but no salmon or steelhead. Further, recovery of the bald eagle population is due to a combination of actions; attributing it to an increase in instream flow triggering "dramatic increases in fish populations" is an oversimplification.

Action Taken: Decline suggestion; text is the same as from the document that was cited and that document withstood much review including review by the agencies that conducted the Pit River study. Furthermore, it seems that eagles will benefit more from increases in populations of salmon because salmon provide more food than trout.

Pg. 15, para. 5 - The scientific name of the Valley Elderberry Longhorn Beetle is *Desmocerus californicus dimorphus*.

Action Taken: Thanks, I needed that!

With regard to increased streamflow raising groundwater elevation and improving health of riparian vegetation, this is not the case with Battle Creek. First, high flows well in excess of any diversion capabilities occur annually that scour and define the limits of the streambed. The minimum instream flows being contemplated do not come anywhere near the annual runoff flow events. Further, the stream and its branches traverse steep canyons with rocky beds. The minimum instream flows will generally occupy the center of the streambed. There is no soil or stream margins that will be noticeably affected by the increase from present minimum flows, and high flows will wipe out any valley elderberry bushes that sprout within the stream margins.

Action Taken: Text modified as "Restored stream flows in Battle Creek would increase the health of the riparian vegetation along the stream, especially in the South Fork where significant side channels and stream-side terraces exist (USBR 1998a)."

Pg. 19, para. 2 - The concern of private hatcheries regarding disease vectors includes predator-borne organisms transferred from areas where wild fish are present to hatchery facilities or water intakes. The waters feeding the hatcheries in the area planned for restoration come from springs, not hydroelectric power canals. Some of the hatchery outflows enter the hydroelectric water conveyance system.

Action Taken: Text modified to read "Though these facilities do not interact with fish populations in the anadromous habitat of Battle Creek, some facilities, such as MLTF's main broodstock facility, are closely proximate to hydroelectric power canals. Concern has been expressed regarding disease transmission between the hydroelectric power canals and these facilities (Phil Mackey, MLTF, presentation to Spring-Run Working Group, 1996). For example, infected juvenile salmon living in unscreened canals could serve as vectors for disease if borne by predators to hatchery facilities."

Pg. 20, para. 2 - The abbreviation BCWG is used for the first time, with no explanation. The first time the Battle Creek Working Group is mentioned is on page 1. Throughout the document BCWG and Working Group are used. For brevity and consistency, it is recommended that only the acronym be used.

Action Taken: Text modified as suggested.

Pg. 20, para. 4 - An opening parenthesis appears to be missing in the second line preceding "PG&E."

Action Taken: Text modified as suggested.

Pg. 21, para. 2 - The ladders modified following Coleman were done in consultation with CDFG specialists in each instance and should be so noted.

Action Taken: Text modified as suggested.

Pg. 22, para. 3 - PG&E does not, "at the request of CDFG, move gravel." PG&E removes gravel when it interferes with operations. PG&E obtains the necessary approvals to perform the work.

Action Taken: Text modified to read "Gravel trapped behind diversion dams higher in the watershed has been removed from the stream in the past (USFRHAC 1989). Presently, PG&E removes gravel which accumulates upstream of their diversion dams when it interferes with operations. CDFG has requested that this gravel be placed downstream of the dams in order to maintain steady supplies of spawning gravel (CDFG streambed alteration permits, on file, Redding, CA)."

Pg. 22, para. 5 - What proof is there regarding the assertion made in the last sentence? There is no basis for the presumption that all

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hatchery fish stocked in the hydroelectric conduits are killed if they pass through the powerhouses? Survival of fish passing through Francis turbines has been documented at other projects.

Action Taken: Text modified to read "Private parties currently stock small numbers of fish in the Battle Creek watershed with the approval of CDFG. One fishing resort stocks 400 sterile rainbow trout per year into the South Fork and another resort owner stocks rainbow trout into hydroelectric canals in the watershed. Neither stocked population is considered to seriously impact anadromous salmonids because the fish stocked in the wild are sterile, and trashracks and hydroelectric powerhouses likely prevent large numbers of live fish from entering Battle Creek."

Pg. 25, para. 5 - This paragraph discusses the Anadromous Fish Restoration Program and mentions the 10 actions including streamflow increases and installation of effective ladders and screens. These action items are important as they form the basis for ongoing discussions between PG&E and the resource agency for restoration efforts. The ten action items and specified streamflows proposed in the AFRP should be listed in this restoration plan.

Action Taken: Text modified as suggested, AFRP table added.

Pg. 26, Table 5 - An item should be added either in 1995 or 1996 regarding commencement of discussions among PG&E and the resource agencies regarding elements of a long-term restoration plan. This work was going on concurrently with development of the initial interim agreement. Also, 1998 should include an item for establishment of a second interim agreement with a potential term of three years.

Action Taken: Text modified as suggested.

Pg. 27, para. 3 - The reference should probably be the 21st century. We are virtually at the end of the 20th century.

Action Taken: The context is restoration within the 20th century; I haven't given up hope yet. Decline suggestion.

Pg. 27, Table 6 - This table should be at the beginning of the report for easy reference by readers.

Action Taken: Text modified as suggested.

Pg. 28, para. 1 - The BCWG was initiated by interested stakeholders, primarily CVPWA and MWD, in an effort to move development of a long-term restoration plan forward at a faster pace than had been occurring. It was not "a response to continuing low fish populations." It also appears that the first and second paragraphs were meant to be one.

Pg. 28, para. 2 - The "A Time for Action" report was developed outside the BCWG. The developers should be cited to avoid the implication that the report was a product of the BCWG. At the very least, it should be stated that the report was developed without any notification to or involvement of PG&E, the primary stakeholder in actions that were proposed.

The third sentence of this paragraph is, at best, confusing. What are the "simultaneously-negotiated historic settlements" that are referenced?

Action Taken: Added reference to first sentence and PG&E disclaimer. Text modified to read: "The BCWG was formed in 1997 in response to the continuing low fish populations and degraded habitat in Battle Creek (USRFHAC 1989), and in order to institutionalize restoration activities in Battle Creek funded by CVPIA and Category III. In recognition of the short time-frame associated with CVPIA and Category III funding and the possibility of institutional inertia, a subgroup of the BCWG that did not

include PG&E, released a working paper in January 1998 entitled "A Time For Action," that was intended to catalyze the current planning process by suggesting a list of possible restoration actions (BCWG 1998). Biological, socio-economical, and political analyses have been conducted in response to this working paper. This present Restoration Plan is a result of these analyses. Furthermore, the Restoration Plan will support formal environmental documentation that will accompany the negotiated settlements.

Pg. 28, para. 4 - We recommend modifying the second sentence in this

unaided upstream migration. Aquatic macroinvertebrates (presuming the authors had intended to mention insects rather than plants) most commonly disperse in a downstream direction during their aquatic phase, and during their adult phase are generally airborne and are not limited by a fish ladder or a small dam.

It is suggested that proposed optimum flows and installation of screens and ladders do not restore ecosystem processes such as "unimpeded water flow unrestricted sediment flow and continuous distribution of organic material and nutrients". This statement greatly exaggerates the effect of Eagle Canyon Dam. Eagle Canyon Dam and the relatively small diversion (70 cfs) does not significantly reduce peak flows affecting geomorphic processes, neither does it significantly hinder sediment flow down North Battle Creek. The fish screen proposed for the diversion is specifically designed to facilitate bedload movement away from the fish screen and past the dam. The effect of unimpeded water flow can also be negative; because the channel below Eagle Canyon Dam is so narrow, the instream flow expected with removal of Eagle Canyon Dam would actually diminish the predicted amount of winter and spring run chinook habitat below what could be achieved with flow control at Eagle Canyon. Finally, installation of the proposed fish screen will enhance the flow of organic material and nutrients by decreasing the fraction of organic material diverted to significantly less than the proportion of the flow diverted.

It is suggested that mechanical fixes are not "ecological stable". PG&E has already agreed that it or future owners would not divert at Eagle Canyon if the fish screen is not functional. The reliability of the proposed design for pool-and-weir fish ladder is much less of a concern. This design is simple, robust, and contains a number of features to protect it from storm damage and to rapidly bring it back into service in the event of sediment or debris accumulation, or some other malfunction. If at some time in the future this diversion ceases to be used and maintained, there are already regulatory mechanisms in place to require its decommissioning.

It is suggested that the proposed optimum flows combined with installation of a reliable fish ladder and screen "do little, if anything to protect the winter-run chinook salmon refugia that exists within Eagle Canyon." As discussed above, this statement is clearly false. Conditions with controlled release of optimum flows at Eagle Canyon are arguably better for winter and spring run chinook than are higher uncontrolled flows without the diversion.

The proposal to isolate water from the North Battle Creek from South Battle Creek is a better hypothetical example of restoring ecosystem function. This action is not entirely beneficial for salmonids, as increased water temperatures would decrease the suitability of steelhead nursery, winter run egg incubation, and spring run holding habitats in South Battle Creek. It would have the effect of restoring a natural continuum of water temperatures in South Battle Creek that would be compatible with natural movement and spawning patterns of spring chinook, as well as minimizing the risk of confusing upstream migrants returning to North Battle Creek.

Action Taken: Text modified as suggested. The whole example of ecosystem restoration has been shifted to the South Fork, in particular the effects of the proposed water isolation facilities on straying and temperature. Text to follow when finalized.

Pg. 33, para. 2 - The identification of user groups dependent on stream and water resources in Battle Creek should include electrical energy consumers.

Action Taken: Text modified as suggested.

It should also be pointed that recreational and commercial fishery interests will continue to operate under strict fishing regulations until delisting of winter-run and potential spring-run occurs. Delisting of these species could take 10-20 years.

Action Taken: Text modified to read: "Increases in fish populations, on the other hand, should benefit recreational industries including fishing clubs and guide services, as well as commercial fisheries, by providing more fish to catch. However, commercial and sport fisheries will likely continue to operate under strict fishing regulations until species listed under federal and State endangered species statutes are fully recovered."

Pg. 36, para. 2 - The comment regarding higher water temperatures in Digger Creek should be confirmed. During review of information for thermal modeling, an error was found in the earlier tabulation of Digger Creek data and temperatures were actually lower than earlier indicated.

Action Taken: Statement about Digger Creek has been removed.

Pg. 39, Table 8 - There appears to be substantial confusion regarding PG&E shareholders and ratepayers and CPUC involvement. Items identifying these entities should be stricken. Also, the use of words such as "essential", "must", "highest certainty", "eliminating mixing", etc., should be avoided as a comprehensive plan that meets the competing interests' needs will require flexibility in some areas. Locking in on words of absolute connotation may hinder the ability of the parties to reach an equitable arrangement for the long term.

Action Taken: I have modified the table to just the "biological" principles, and not the economic ones. The firm language is maintained to reflect the fact that these statements are "principles" rather than, say, "wishes."?

Table modified to read:

Table 10. Biological principles that the USFWS, NMFS, CDFG, and USBR consider essential for salmonid restoration and a necessary component of any negotiated settlement with PG&E.

Biological Effectiveness – Restoration actions must incorporate the most biologically effective remedies that provide the highest certainty to successfully restore ecosystem functions and self-sustaining populations of native fish in a timely manner.

Restoring Ecosystem Function – Restoration actions must incorporate measures that mimic the hydrologic conditions under which Battle Creek anadromous fish resources evolved by increasing baseflows and eliminating mixing of North Fork and South Fork waters.

Biological Certainty – Restoration actions must provide maximum long-term effectiveness by minimizing long-term dependence on the integrity of man-made restoration actions and the cooperation of future project owners and operators.

Pg. 40, para. 1 - This paragraph misstates the FERC license minimum flows. Those remain at 3 cfs and 5 cfs for the diversions on North and South Battle Creeks, respectively. The 30 cfs at Eagle Canyon, cessation of diversion at Wildcat, and 30 cfs at Coleman are elements of the interim agreement between PG&E and USBR. The paragraph needs to be rewritten to state the situation accurately.

Action Taken: Text modified to read: " Existing FERC minimum flows within the anadromous portion of the watershed are 3 cfs at diversions in the North Fork and 5 cfs at diversions in the South Fork (U.S. Federal Power Commission 1973). An agreement between PG&E and USBR (USBR 1998a) specifies minimum flow releases of 30 cfs downstream of Eagle Canyon and Coleman dams and a cessation of diversions at Wildcat dam. However, the minimum flows set in USBR (1998a) are scheduled to expire in 2001, and absent a long-term agreement, minimum flows would presumably revert back to 3 cfs below all PG&E diversion in the North Fork and 5 cfs below all PG&E diversion in the South Fork consistent with PG&E's FERC license. "

Pg. 40, para. 5 - This paragraph states that modeling results only roughly estimate possible water temperature under a variety of restorable flow conditions. This statement drastically underplays the temperature model's capabilities and completely ignores the effort that the BCWC Biological Team put forth in its efforts of re-evaluation of the TRPA's model, the model verification, and comparative assessment of various release scenarios.

The SNTEMP temperature model is a mathematical tool that incorporates the flow and heat transfer mechanisms necessary to estimate water temperature in the stream reach. The model, once properly calibrated and verified for the application site, is considered the best-available technology to help shape the various management scenarios under consideration. In 1998, PG&E, in conjunction with TRPA, undertook the task to extend the TRPA's model application, during which the assumptions used in their earlier modeling studies (submitted to CDFG as TRPA 1998c and 1998d) were corrected to have a more realistic basis. The model was further verified and the results were presented to the Biological Team. The verification task confirmed the model is accurate to 0.5 to 1 C. Thereafter, PG&E submitted a series of model simulation results under a variety of restorable flow regimes as recommended by the Biological Team. In that simulation process, PG&E uncovered an error in TRPA's Digger Creek temperature estimate, and took action to correct the error. The revised model with the Digger Creek correction has been available for the team to use for some time and PG&E believes that this model will best simulate stream temperatures for the desired streamflow and meteorology.

Shortfalls of the original model that were subsequently corrected included the following:

1) The water was not routed from the upstream network, i.e., each stream reach was treated in isolation and the starting temperatures were held constant for all scenarios.

2) The starting temperature at each dam (e.g., Coleman Dam) represented actual data for that specific year regardless of whether the flow condition is representative of the proposed configuration. For instance, actual data always included mixing effect from North Battle Creek and this initial condition will significantly underestimate temperature regime for a scenario with different configuration where connector(s) between the powerhouse tailrace and canal are proposed.

3) The model was applied for a specific year in which the weather conditions are unique to that individual year. This application is biased and may not be appropriate for the long-term assessment.

4) The model, originally developed in 1989, was not modified to reflect the changes made in 1995 when spring flows immediately downstream Eagle Canyon Dam were re-directed to North Battle Creek, thereby, making model

prediction incompatible with 1995 observation.

In its present, refined form, the model is an accurate predictor of instream water temperatures and results fall within ½ to 1(C of actual measured temperatures.

Action Taken: The resource agencies, and Kier Associates, currently doubt the applicability of the PG&E SNTEMP model, especially for determination of absolute temperatures, primarily because it does not seem to match with actual data and the model was still significantly flawed the last time that it was presented, but also because it has not been thoroughly reviewed since its 10/9/98 release (the more recent, corrected 12/10 release was not downloadable and, therefore, was never received). You will recall that the original, stated intent of the Biological Team process was to use an IFIM/WUA based approach to determine appropriate flows for fish in Battle Creek. The SNTEMP was to be a check to make sure that temperatures were not too high; we never intended that flows be determined primarily in response to the temperature model. I would recommend that if flows were to be primarily determined by a temperature model, then a more sophisticated model would need to be developed than the SNTEMP. In the Sacramento River, for example, where temperature management was a primary objective, as many as 5 separate temperature models were developed. However, managing flows based primarily on temperature was never a primary objective of the Biological Team.

It has been pointed out that because 1) biologically optimum flows represent nearly all available flows in the South Reach, and 2) proposed connectors to prevent straying also prevent the mixing of North Fork water, then a precise temperature model is not needed unless it would suggest that flows in excess of the biologically optimum flows should be released from Inskip and/or Coleman. If all the water that is available is used in the stream, then there is nothing left to model.

Pg. 41, para. 1 - This paragraph states that temperature data (both monitoring and modeling) were compared to thermal criteria in Table 11 to determine the maximum restoration potential for the various reaches. The focus of the analysis was on summer and fall months where high water temperatures pose risk to salmonids (i.e., winter-run and spring-run spawning). The specific time period addressed was June 15-June 30 for winter-run spawning and September 15-September 30 for spring-run spawning. PG&E is concerned that the window for winter-run spawning maybe too narrow. Winter run spawning takes place from about mid April to mid August (Table 1) and observation data collected in Battle Creek in 1965 and 1995 show salmon migration into Battle Creek as late as July. To fully evaluate the restoration potential of each reach for the temperature sensitive winter run, temperature modeling should be done to address the actual restorable temperature regime in both North and South Battle Creeks. This temperature modeling should also examine the potential temperature increases in South Battle Creek due to the elimination of the mixing of North Battle Creek water which is currently proposed by the resource agencies.

Action Taken: Text modified. The following sentence was added to descriptions of habitat grades D and E: "Habitats of grades "D" and "E" will contribute more to winter-run restoration in years when winter-run spawn early but may contribute little in years when winter-run spawn late in the season."

Pg. 41, para. 2 - No citation was provided for Cairns (1990) and therefore it is impossible to review discussion relative to this article.

Action Taken: Text modified as suggested.

Pg. 42, para. 1 - This paragraph states that water temperatures under the restored regime using the SNTEMP indicate a range between 60(F and 70(F throughout the mainstem Battle Creek. TRPA 1998c predicted water temperatures in the mainstem under both 1988 (warm) and 1995 (cool) meteorological conditions. In the model runs that most closely

represent the restored flow regime in Table 21, maximum daily average water temperatures will range from 75(to 73(F, respectively.

Action Taken: Text modified to read: " Water temperature plays a strong role in determining the location of spring-run chinook holding habitat (CDFG 1998b). Suitable temperatures are optimum if less than 60.8°F and completely lethal greater than or equal to 80°F (Table 13). In July and August of 1992 and 1995, when water temperature data were available in Deer and Mill creeks, average summer water temperatures in these holding habitats were less than 66.5°F and were usually less than 62°F (Figure 5 through Figure 8). Predictions of water temperatures under a restored flow regime in Battle Creek using the SNTMP model (TRPA 1998c and 1998d) indicate a range of water temperatures between 60° and 70°F throughout the mainstem Battle Creek and the North Fork, and in the upper reaches of the South Fork. This estimated temperature regime, with varying degrees of suitability throughout Battle Creek, is much like that found in other streams supporting spring-run chinook (Figure 9 and Figure 10)."

Pg. 42, para. 2 - The second sentence in this paragraph appears to be referring to winter-run spawning and egg incubation. It states that "suitable temperatures are optimum if less than 60.8(F and completely lethal greater than or equal to 80(F (Table 11)." This sentence appears to be incorrect and should be revised. According to Table 11, optimum temperatures for egg incubation to the eyed stage would be temperatures less than 58(F (8% mortality at 24 days) and not less than 60.8(F (approximately 15 to 25% mortality at 20 days). According to Table 11, completely lethal temperatures for egg incubation to the eyed stage would be greater than 62(F (100% mortality at 7-12 days), not 80(F.

Action Taken: Text modified as suggested.

This paragraph goes on to state that in 1995, temperatures in the entire North Fork were less than 58(F and that temperature in the entire South Fork were less than 60(F. This statement should be qualified that the temperature regime described in Figures 13 and 14 are average monthly temperatures and that 1995 represented not only a greater than average water year, it also represented below average air temperatures. For example, of the 11 available years (1988-1995) of climate data from Redding Airport, June temperature ranked 11th (or the coldest June for the 11 year period) and July ranked 8th. Thus, the temperature regimes portrayed in Figures 13 and 14 do not represent the average year early summer temperature range for these stream sections. Average monthly temperatures also tend to mask critical daily temperatures that are important to incubating egg embryos. According to 1995 graphical data supplied to the BCWG Biological Team by CDFG, July water temperatures in the Wildcat reach of North Battle Creek exceeded 59(F for about 18 days, and equaled or exceeded 60(F for about 15 days.

CDFG 1995 data also does not support the statement that water temperatures in entire South Fork remained below 60(F in June and July (Figure 13). Water temperatures recorded for the Coleman reach of the South Fork show that monthly average water temperatures in July were probably closer to 63(F with daily average water temperatures reaching 64(F.

PG&E recommends that temperature modeling data be used to characterize water temperature regimes anticipated under various flow scenarios, average and extreme climatic conditions, and facility modifications. The BCWG Biological Team have verified the accuracy of the model to within 0.5 to 1(C and have refined certain assumptions in the original TRPA SNTMP temperature model to improve its prediction capabilities. Existing condition temperature data has value, but it is limited in that it only represents temperature observed at specific streamflow and meteorological conditions. The original SNTMP model made certain

assumptions that resulted in less accurate temperature prediction than are currently needed. In addition, the temperature prediction provided in TRPA 1998c and 1998d assumes that there will be "mixing" of South and North Battle Creek water. Current considerations not only include higher instream flows, they also address options for minimizing the mixing of South and North Battle Creek waters. These options will ultimately increase water temperatures in South Battle Creek. Thus, existing condition temperature data do not adequately address restoration options being considered. These considerations should be more adequately addressed in this restoration plan.

Action Taken: Again, the resource agencies, and Kier Associates, currently doubt the applicability of the PG&E SNTMP model, especially for determination of absolute temperatures, as noted above. Addition of the South Fork ecosystem function example includes the following points (the full, new text is unavailable now but will be shared with you before we finalize the report).

The biologically optimum flows that have been embodied within proposals for restoration contain many features that constitute temperature control consistent with the Plan's emphasis on ecosystem restoration. These features of the proposed flows preclude the need for more sophisticated temperature modeling:

1) In the reaches of the South Fork Battle Creek that were in the mid to high elevations, that are capable of providing habitat for temperature-sensitive early stages of anadromous fish, the recommended flows in the summer period approximated the average natural flows for that period thereby maximizing the temperature benefits produced by flow, 2) The recommended releases of all spring water sources currently diverted to the hydropower system is a full release during the summer period, further maximizing temperature benefits produced by springs, 3) In the reaches of the North Fork Battle Creek, which is dominated by cold water springs in the summer period, the recommended flows exceed those that were tested in the 3 year interim flow augmentation agreement (1995 to 1997) that were empirically shown to provide adequate temperatures for the early life stages of anadromous fish, and 4) At the lowest elevation dams in the system implementation of the decommissioning alternative found to be feasible by the USBR would further maximize the temperature control by leaving all the accretions in the stream from above these dams. The only temperature control capability not integrated into the system is the mixing of North Fork Battle Creek water with South Fork Battle Creek water. This control technique has not been integrated because the false attraction of natal North Fork fish to the low elevation reaches of the South Fork would reduce the survival of these fish over what they could achieve in the North Fork, especially during powerhouse shutdowns. In addition the temperature influence produced by mixing the North Fork water is limited to a small fraction of the reach in the low elevation areas where the climate is warmer.

If the biologically-optimum flows and tailrace connectors that have appeared in various restoration proposals in the past several months are not eventually agreed upon in the current negotiations, then the process of determining flows will be back to where we started in April 1998. If our work is thusly unraveled, then I would recommend turning to the comprehensive temperature data collection currently under way by the DWR and that comprehensive temperature models, including ones more sophisticated than the SNTMP model, be developed.

Pg. 51, Figure 9 - The figure title indicates that summer temperatures were based on TRPA-SNTMP and 1996 observed data. The flow assumptions for the various reaches were not indicated in the figure as they were for Figure 10. Additionally, under "Temperature Data Sources" in figure, 1995 is listed rather than 1996. Is this 1996 or 1995 data?

Action Taken: 1995 data. Text modified as suggested.

Pg. 52, Figure 10 - Based on comments provided for Figure 9, is the temperature data source 1995 or 1996?

Action Taken: 1996 data. Text modified as suggested.

Pg. 53, Figure 11 - The figure legend describes chronic stress for winter-run spawning habitat as temperatures greater than 70(F). This

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value appears excessively high, and Table 11 provides no basis for this criteria. Based on data provided by CDFG to the BCWG Biological Team, we suggest this temperature value should be 64(F. This data showed 100% mortality at 7 days with a temperature of 64(F. This comment would apply to Figure 14 as well.

Action Taken: Text modified as suggested.

Pg. 57, Figure 15 - Page 57, Instream Flow, Figure 15-PG&E recommends that the following sentence be rewritten as follows: Habitat in the Wildcat reach would be reduced to "C quality" status if instream flow releases were insufficient to maintain water temperatures for winter-run chinook incubation at levels that avoid chronic problems. PG&E disagrees that potential restored habitat should be categorized as "good" when chronic temperature problems exist (i.e., at temperatures greater than 62(F where 100% egg mortality can occur in 7 to 12 days).

Action Taken: Text modified to read as "C quality". More emphasis has been placed on the fact that "maximum potential restoration" is the yard stick used to gauge all possible restoration actions. I have been unable to find records of "chronic temperature problems" or temperatures >62 °F during the winter-run egg incubation period in the Wildcat reach.

In the second sentence, we recommend that the term "excellent status" be replaced by the term "B quality status" to be consistent with the existing ranking terminology.

Action Taken: Text modified as suggested.

Pg. 58, Figure 16 - See comments for Figure 15.

Action Taken: Text modified as suggested.

Pg. 61, Figure 19 - See comments for Figure 15.

Action Taken: Text modified as suggested.

Pg. 63, para. 2 - In the Eagle Canyon reach, juvenile rearing is limiting at flows up to approximately 35 cfs, but then is overtaken by spawning habitat as the limiting factor for higher flows.

Action Taken: Text modified as suggested.

Pg. 63, para. 5 - This paragraph states that temperature monitoring and modeling indicated that the Inskip and Wildcat reaches were the most sensitive to flow-related temperature changes. The Coleman reach has also been identified as a temperature-sensitive reach. This statement is only true if there is a connector installed to prevent mixing of the cool Inskip tailrace water. The rate of temperature increase is not just a function of flow, its also depends on the starting temperature.

Action Taken: Acknowledge, no changes made.

Pg. 63, footnote 20 - This statement should be clarified to indicate that the temperature modeling scenario referred to was with the Coleman connector in place.

Action Taken: Text modified as suggested.

Pg. 64, para. 1 - Insert the following words into third sentence as follows: Eagle Canyon springs near the diversion, previously carried by PG&E into the Eagle Canyon Canal, would continue to be released..

Action Taken: Text modified as suggested.

Pg. 73, Table 24 - The word "net" from the figure title should be removed. The term "Mixing Minimizer" in the table header should be

revised if direct connectors are employed. More accurate descriptions might be Limiter or Eliminator.

Action Taken: Text modified as suggested.

Page 74, para. 1 and 2--This section refers to flow fluctuations and the potential need for ramping rate requirements. As stated in the plan, flow fluctuations could occur for primarily three reasons including: generation changes at powerhouses, emergency powerhouse shut downs, and scheduled powerhouse and canal maintenance. Powerhouses located on the Battle Creek system are not operated as peaking plants and therefore streamflow fluctuations associated with generation changes do not occur.

I don't understand how stream flow changes would not occur when generation changes are made. Emergency shutdowns or powerhouse trips occur infrequently and would cause minimal impacts to anadromous fish populations. **Perhaps infrequent, but potentially very harmful.** Scheduled maintenance on powerhouses and canals occurs on an annual basis and therefore presents little risk to aquatic resources from upramping or downramping operations. **With fish spawning and rearing year-round, the amount of impact will clearly be based on the rate at which ramping occurs.** The plan should do a better job of qualifying the potential risk to anadromous from these type of operations.

Action Taken: No changes made. Responses to individual points are in bold in the above paragraph.

PG&E has recently evaluated the potential for increases in turbidity associated with project operations. Those studies were presented to the RWQCB in 1997 indicating that there were minimal turbidity impacts associated project operations. In order to minimize water quality impacts in project canals and streams, powerhouse loads are brought back up in a step-wise fashion. These startup procedures also serve to minimize potential stranding impacts to anadromous fish.

Action Taken: Can you provide me with this documentation?

Studies on the Sagit and Sultan rivers were primarily carried out to address impacts associated with daily hydroelectric peaking operations. These studies found that peaking operations could cause significant cumulative mortalities. On the Sultan River, the resource agencies recommended downramping regimes of 1 in/hr to 6 in/hr depending on season, river stage, and time of day. Study sites on the Sultan River were located in the lower 3 miles of the river where the river was approximately 200 ft wide with a gradient of approximately 20 ft/mile. The study reach contained several gravel bars and side channels. Stream channel characteristics of the Battle Creek project affected by project operations are much different than those of the Sultan River. Average stream gradients are much higher and alluvial flats and sides channels are lacking, thus minimizing the potential for stranding. Future scheduled maintenance on powerhouses and associated canals will typically be done during the winter and spring. During this period, base flows in project streams are relatively high and therefore this condition will also pose little risk stranding impacts. PG&E is willing to work with the resource agencies to identify reasonable ramping rates to protect aquatic resources. However, ramping rates should be based on existing site conditions and ongoing operation concerns. Ramping rates should not be over restrictive based on non-applicable studies.

Action Taken: Acknowledge, no changes made.

Pg. 74, para. 4 - The fishladders at all six diversions have been modified over their lifetime, not just Eagle Canyon. The existing ladder at Eagle Canyon is closed per the interim agreement with USBR and at the request of resource agencies. It is not non-operational.

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The statement regarding the Wildcat ladder is incorrect. It is not inefficient for its design flows. Further, there is no indication of damage from falling rock. In fact, it is rather well-protected by a large boulder in the stream just upstream of the dam.

The fishladder at Inskip is a steel Alaska steep pass set within portions of the original concrete step pool ladder.

Action Taken: Text modified to conform with existing version of DWR report.

Pg. 75, para 1 - The statement that fish screens are less reliable and harder to maintain than connectors is questionable and has no basis.

Action Taken: Acknowledge, no changes made.

The statement made that tailrace connectors will isolate wild anadromous fish from CNFH water supply is false. Under present proposals, anadromous fish will be present above North Battle Creek Feeder, and Eagle Canyon, Inskip, and South diversions.

Action Taken: Text modified as suggested.

Pg. 75, Table 25 - The estimated cost figures need to be updated.

Action Taken: Text modified as suggested.

Pg. 75, para. 2 - To be fully truthful, it should also be stated that the anti-straying measures will result in elevated water temperatures in South Battle Creek that will have negative impacts on incubation habitat for winter-run and holding habitat for spring-run chinook salmon, as well as poorer nursery habitat for steelhead juveniles.

Action Taken: That the connectors will curtail the artificial cooling which exists under the present system is now covered more fully in the water temperature section.

Pg. 76, para. 4 and 5 - The word "problem" in the first sentence of each paragraph should be changed to "concern". The concern regarding straying from interbasin transfer of water is not a demonstrated problem.

Action Taken: CDFG, USFWS, and NMFS consider the false attraction situations to be problems. Interbasin transfer of water has been demonstrated as a problem at Coleman Powerhouse as well as other locations outside of Battle Creek.

Pg. 76, para. 6 - In last sentence of paragraph, the word planned should be struck out. Planned outages are now scheduled for the winter/spring period and water temperatures would not be a concern.

Action Taken: Text modified by removing "planned and unplanned,"

Pg. 77, para. 1 - The last sentence should be modified to read "...problematic, mixing water from Eagle Canyon Dam with South Fork water is more..."

Action Taken: Text modified as suggested.

Pg. 77, para. 4 - The cost for South Powerhouse tailrace connector should be consistent with cost in Table 25 (as updated).

Action Taken: Text modified as suggested.

Reference to the partial flow separator as an alternative to South Powerhouse tailrace connector should be deleted.

Action Taken: Text modified as suggested.

Pg. 80, para. 1 - The statement that the PG&E model is not complete is incorrect and unfounded. The model is the aforementioned refinement of the TRPA SNTMP model and results have been routinely forwarded to resource agencies as modeling of various scenarios have been requested. It is the most accurate tool currently available to assist with restoration planning.

Action Taken: text modified with a version of the paragraph, above, that was suggested by CDFG

Pg. 80, para. 2 - Construction of tailrace connectors at South and Inskip powerhouses will impact temperatures in the South Fork. Use temperature modeling data discuss this impact/downside to this action.

Action Taken: text modified with a version of the paragraph, above, that was suggested by CDFG, and fuller explanation of the connectors in the South Fork example of ecosystem functions.

Pg. 80, para. 3 - This is worded differently than on page 22. It states here that PG&E moves gravel downstream "during dredging operations". A more accurate representation would be: PG&E, where possible and at the request of CDFG, has voluntarily passed gravel over the dams during dredging operations when removing gravel from diversion pools.

Action Taken: Text modified to match that on page 22 (see above comment).

Pg. 80, para. 5 - PG&E has operated the Battle Creek Project since 1919. Although some relatively minor amount of amounts gravel have been removed from Battle Creek during maintenance activities, these losses appear to be negligible as described in the draft report entitled "Spawning Gravel Resources of Battle Creek, Shasta and Tehama Counties, February, 1991." This study was conducted by TRPA under contract to CDFG and the work was actually performed by Mathias Kondolf from UC Berkeley. As stated in the report, the natural geology of the area will continue to provide gravel to the Battle Creek watershed although this source is not abundant. The primary factors limiting the distribution of gravels in the system can be attributed to 1) the high shear stresses over most of the bed and the relative lack of suitable sites for deposition, and 2) the relatively low recruitment rates for the lithologies in the watershed and trapping of sediments by Macumber Reservoir. Gravel movement past existing diversion dams is accomplished by flushing sediment through the low level outlet at the base of the dams or by mechanically removing the material. Flushing sediments through the dam outlet is accomplished by opening the outlet during high spill flows and closing the outlet as high flows recede. This method is preferred by PG&E and is recommended by the Kondolf study. This process moves sediment through the diversion in a way that mimics natural gravel transport and, additionally, it reduces PG&E maintenance costs. If dredging is necessary at selected sites, PG&E has agreed (as already indicated in this report) to put this gravel back into the stream. These actions continue to route gravel through the system and have little impact on gravel recruitment down stream (particularly on high gradient stream reaches of North Battle Creek). Dam removal is not necessary to restore ecosystem processes, as reported by TRPA studies conducted in 1991.

Action Taken: Text modified as suggested.

Pg. 84, para. 3 - A ramping rate of 0.00 is not a rate function.

Action Taken: Text modified to read "rates less than 0.17 feet/hour".

PG&E suggests the following wording for this action item: Establish appropriate ramping rates using best available information and

Appendix B. Responses to written comments to the draft restoration plan.

professional judgment or conduct a study to identify ramping rates that prevent stranding of fish. (Also see comments for Page 74.)

Action Taken: Such a future study is suggested on page 85 in the section "Evaluations And Studies Necessary For Salmonid Restoration".

Pg. 85, para. 6 - Follow the last sentence with: Test fish (hatchery or other sources) must demonstrate equivalent behavior of wild fish.

Action Taken: Text modified as suggested.

Pg. 85, para. 7 - delete last sentence; it is unnecessary.

Action Taken: Text modified as suggested.

Pg. 89, Literature Cited - Reference for Cairns 1990 not provided.

Action Taken: Text modified as suggested.

Pg. 100, Literature Cited - Reference for USFWS 1998h is missing.

Action Taken: Text modified as suggested.

Sincerely,
Kier Associates
Michael. B. Ward

Comments from NMFS

From: Alice Berg <Alice.Berg@noaa.gov>
To: wardski@televar.com
Subject: Re: Please help

The documents to cite:

USDA-FS Lassen National Forest (LNF). 1997. Biological Assessment for Implementation of the Lassen National Forest Land and Resource Management Plan (as amended). September.

USDA-FS Lassen National Forest (LNF). 1998. Addendum to the September, 1998, Biological Assessment for Implementation of the Lassen National Forest Land and Resource Management Plan (as amended). May.

USDC National Marine Fisheries Service (NMFS). 1998. Biological and Conference Opinion on the Implementation of Lassen National Forest Land and Resource Management Plan as amended by PACFISH. NMFS Southwest Region, Long Beach, California. June.

USDA-FS and USDI-BLM. 1995. Environmental Assessment for the Interim Strategies for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH). USDA (Forest Service), USDI (Bureau of Land Management). February.

Background:

During ESA Section 7 consultation with NMFS, the Lassen NF recognized the need to treat Battle Creek watershed as a key watershed. Treating Battle Creek as key will include management direction equivalent to designated key watershed under PACFISH, including priority for watershed analysis, maintenance and restoration projects, and Riparian Habitat Conservation Area (RHCA) management direction for category 1,2,3, and 4 streams and water bodies. In addition, the LNF will revise its long term monitoring plan to include stream reaches in the Battle Creek watershed. (Notice the language difference- "treat" as opposed to "designate". Designation requires separate NEPA according to the LASSEN, so for now its "treat as key watershed").

Hope this helps.....

Action Taken: Text modified as suggested throughout above email.

Comments from NMFS

777 Sonoma Ave
Santa Rosa, Ca. Rm 325
(707) 575-6050; Fax (707) 578-3435

October 23, 1998

F/SWR4:IG

Michael B. Ward
Kier Associates
P.O. Box 85
2360 Highway 20
Wauconda, WA 98859

Dear Mr. Ward:

Thank you for your letter dated October 16, 1998, requesting review and comments on the document entitled: Final Draft, Battle Creek Salmon and Steelhead Restoration Plan.

The following specific comments are provided:

Forward

The second paragraph should be expanded to include all of the federal listed species (Central Valley winter-run chinook and steelhead) and the proposed for listing species (Spring-run, Fall and Late-fall chinook salmon). By including the other species, we emphasize the importance of Battle Creek in recovering Central Valley anadromous fish stocks and the need for to restore this watershed.

Action Taken: Text modified as suggested.

Resident Fish Populations

The name for squawfish has recently been changed to pikeminnow

Action Taken: Text modified as suggested.

Fisheries Management

There should be some discussion on the movement of the winter-run supplementation project to the Livingston Stone hatchery at Shasta Dam.

Action Taken: Text modified as suggested.

Summary of Past Restoration Efforts

On page 27, the third full paragraph mentions that an interim barrier to the tailrace at the Coleman powerhouse was being installed. This action did not happen in 1998; and it remains unclear on who would be responsible for its installation and maintenance.

Action Taken: Acknowledge comment.

Straying and False Attraction

See comment above for Past Restoration efforts.

Action Taken: Acknowledge comment.

Natural Barriers

The last sentence and, potentially, physical modification of new barriers. The word "new" should read "old" or "all" naturally formed barriers.

Action Taken: Text modified as suggested.

Appendix 1 List of Participants

This list needs to be updated as NMFS was at all meeting except four (Feb 97, Apr 97, May 97, and Aug 98)

Action Taken: Text modified as suggested.

If you have any questions concerning the above comments please contact Mr. Ian Gilroy of my staff at (707) 441-3576.

Sincerely,

James R. Bybee
Habitat Conservation Manager
Northern California

Comments from BCWC

Date: Thu, 22 Oct 1998 15:20:44 -0700
From: Robert Lee <rlee@lassen.com>
To: wardski@televar.com
Subject: Battle Creek restoration plan doc

Thanks Mike for the chance to review the final draft of the plan. I only have a couple of comments:

1) The figures (pages 45-54, 71) should face right, not left.

Action Taken: Text modified as suggested.

2) The report badly needs a good (but simple) map, showing the reaches, canals, dams, and natural barriers.

Action Taken: Text modified as suggested.

3) Regarding the next to last paragraph on page 27, which says "The ... RCDs received...grant to fund the BCWProject which lead to the formation of the BCWC."

Action Taken: Text modified as suggested.

Actually, the BCWC was in formation some time before we heard about the BC Project, and we had received organizational help from two other conservancies (Mill and Deer Cks). The BC Project has been a big help to us, but we would have formed without them. I think that we heard about the BC Project from Harry.

Action Taken: Text modified as suggested.

I want to make sure that your report does not give the impression that the Conservancy was formed out of a conscious effort by outside forces. We really sprouted locally, but we are grateful for the outside help.

Action Taken: Acknowledge comments.

Bob Lee
BCWC