Changes to Battle Creek Hydroelectric Project to Facilitate Fish Passage

Thomas E. Hepler, P.E.1

Abstract

Battle Creek is located in northern California and is a cold water tributary to the Sacramento River. Development of Battle Creek for hydroelectric power generation began in the early 1900s and resulted in the eventual construction of five diversion dams on the North Fork and three diversion dams on the South Fork, along with a complex canal system, to support five high-head, low-volume powerplants. The Battle Creek Hydroelectric Project has been owned and operated by the Pacific Gas and Electric Company (PG&E) since 1919, and is currently licensed by FERC through 2026. Declining salmonid populations in the Sacramento River system, aggravated by ineffective fish ladders, unscreened diversions, and inadequate streamflows, resulted in a multi-agency agreement with PG&E in 1999 to pursue a plan for Battle Creek that would restore and enhance approximately 48 miles of anadromous fish habitat while maintaining the economic viability of the Hydroelectric Project. The Battle Creek Restoration Project includes the installation of fish screens and ladders at three diversion dams, the removal of five diversion dams, the construction of two tailrace connectors and a penstock bypass to prevent canal flows from entering the South Fork; and an increase in streamflows by reducing diversions. Contracts for the project work on the North Fork were awarded in 2009 following FERC approval of PG&E’s license amendment application, with the remaining work to be contracted as additional approvals and funding become available. This paper will describe the NEPA/CEQA compliance process, final design features, and construction status for the Restoration Project.

Introduction

The Battle Creek Watershed lies on the volcanic slopes of Mt. Lassen in northern California, in Shasta and Tehama Counties. Battle Creek, a tributary to the Sacramento River, extends through remote, deep, shaded canyons and riparian corridors. The mountain stream is maintained by cold spring-fed water with relatively high flows throughout the year, with mean average daily flows for a drainage area of 357 mi² ranging from 200 ft³/s to 1,000 ft³/s. Prior to development of the watershed, Battle Creek provided a contiguous stretch of prime habitat for anadromous chinook salmon and steelhead trout from its confluence with the Sacramento River upstream to natural barrier waterfalls on each of two forks. Declining salmonid populations in the Sacramento River system have resulted in increased restoration efforts to preserve and enhance current populations, while addressing the needs of various stakeholders.

Fish habitat in Battle Creek has been primarily affected by the early development of a privately-owned hydroelectric project and the construction of a federal fish hatchery.

1 Civil Engineer, Bureau of Reclamation, P.O. Box 25007, Denver, Colorado 80225, thepler@do.usbr.gov
The Battle Creek Hydroelectric Project was constructed within and adjacent to Battle Creek and its tributaries in the early 1900s, consisting of numerous small diversion dams and over 40 miles of canals to support five high-head, low-volume powerplants. The Hydroelectric Project (Project No. 1121) has been owned and operated by PG&E since 1919. The project was initially licensed by the Federal Power Commission in 1932, and was relicensed by the Federal Energy Regulatory Commission (FERC) in 1976 for a period of 50 years. The Coleman National Fish Hatchery (CNFH), located downstream of the Hydroelectric Project, was constructed in the 1940s by the Bureau of Reclamation (Reclamation) to mitigate for the anadromous fish impacts associated with the construction of Shasta Dam on the upper Sacramento River.

PG&E agreed in 1999 to work cooperatively with federal and state regulatory agencies towards a cost effective and equitable plan to address existing problems associated with ineffective fish ladders, unscreened diversions, and inadequate streamflows, including the removal and modification of its Battle Creek facilities. Reclamation entered into a Memorandum of Understanding (MOU) with the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), the California Department of Fish and Game (CDFG), and PG&E to pursue a restoration plan for Battle Creek. Initial funding for the planning and implementation of the Battle Creek Salmon and Steelhead Restoration Project was provided under the joint federal-state CALFED Bay-Delta Program. Additional CALFED funding was provided to the USFWS for improvements to the CNFH intake structures and seasonally-operated barrier weir.

**PROJECT PURPOSE**

The Battle Creek Working Group, consisting of interested stakeholders and state and federal agencies, was formed in 1997 to identify opportunities for salmon and steelhead restoration in the Battle Creek Watershed. The efforts of this working group led to the development of the 1999 MOU, and subsequently the funding to support the restoration efforts on Battle Creek. The project purpose is to restore and enhance approximately 42 miles of anadromous fish habitat in Battle Creek and an additional 6 miles of habitat in its tributaries. Habitat restoration and enhancement would enable safe passage for, and the growth and recovery of naturally-produced salmonids, including three federally-listed species: the Central Valley spring-run Chinook salmon, the Sacramento River winter-run chinook salmon, and the Central Valley steelhead. The majority of the Restoration Project can be accomplished through modification of the Hydroelectric Project. The goal of the Restoration Project is to restore anadromous fish habitat while minimizing the loss of clean and renewable energy produced by the Hydroelectric Project. Support for the Restoration Project comes from local residents, environmental organizations, the Battle Creek Watershed Conservancy, PG&E, and local, state, and federal agencies. Reclamation’s responsibilities include overall project management (including budgets and schedules), development of project designs and specifications, contract administration, construction management, and preparation of all environmental compliance documents. The California Department of Water Resources (CDWR) assisted Reclamation by designing all fish screen and ladder facilities.
A comprehensive plan to restore and enhance fish habitat was first conceived during development of the MOU. This plan included the removal of five small hydropower diversion dams and the modification, by screening and laddering, of three other diversion dams. The project area consists of the portion of the Hydroelectric Project between the Coleman Powerhouse tailrace and the natural barrier waterfalls on the North and South Forks of Battle Creek, as well as all access roads and staging areas necessary to implement the required hydropower facility modifications. Existing features of the Hydroelectric Project and proposed Restoration Project limits are shown on Figure 1.

The Restoration Project supports restoration directives and goals of the Central Valley Project Improvement Act (CVPIA) Anadromous Fish Restoration Program; the CALFED Bay-Delta Ecosystem Restoration Program; the California State Salmon, Steelhead Trout, and Anadromous Fisheries Program Act; the Upper Sacramento River Fisheries and Riparian Habitat Management Plan; the CDFG Central Valley Salmon and Steelhead Restoration and Enhancement Plan; the CDFG Restoring Central Valley Streams – A Plan for Action; the CDFG Steelhead Restoration and Management Plan for California; and the NMFS Recovery Plan for Sacramento River Winter-Run Chinook Salmon.

ENVIRONMENTAL COMPLIANCE

An interdisciplinary environmental team, consisting of members from Reclamation, USFWS, NMFS, CDFG, PG&E, FERC, and the California State Water Resources Control Board (SWRCB) was created to identify Restoration Project environmental compliance requirements and to develop the necessary documentation to meet those requirements. Primary requirements stem from the National Environmental Policy Act (NEPA), the California Environmental Quality Act (CEQA), the Endangered Species Act (ESA), and the Clean Water Act (CWA). Environmental compliance was linked with project designs to minimize environmental impacts, streamline the analysis of environmental consequences, and ensure that all impacts are adequately mitigated.

As lead federal agency for the planning and implementation of the Restoration Project, Reclamation was responsible for ensuring NEPA compliance. The Federal Power Act (FPA) establishes with FERC the exclusive authority to license nonfederal water power projects on navigable waterways and federal lands. PG&E was required to file an application with FERC for an amendment to PG&E’s existing license to operate the hydropower facilities on Battle Creek that would be affected by implementation of the Restoration Project. FERC, a cooperating federal agency, must ensure that proposed changes in the Hydroelectric Project comply with NEPA prior to issuing the license amendment. All FERC licensing actions in California require Clean Water Act Section 401 certification from the SWRCB, which was designated as the state lead agency to ensure CEQA compliance. A final Environmental Impact Statement/Environmental Impact Report was issued for the Restoration Project.
Figure 1. Existing features of the Battle Creek Hydroelectric Project
Impact Report (EIS/EIR) was issued in July 2005 for the Restoration Project, and includes background information and analysis of potential impacts.

Alternatives to the proposed Restoration Project were developed through a public involvement process, and were analyzed in the joint NEPA/CEQA environmental document (EIS/EIR). These included the “No Action” alternative, resulting in no change to the Hydroelectric Project, and numerous action alternatives consisting of various combinations of dam decommissioning and removals, fish screen and ladder improvements, and increased streamflows below dams. Increased flows will increase spawning and rearing habitat with cooler water temperatures, and facilitate passage over natural barriers. An Action-Specific Implementation Plan (ASIP) was developed to serve as the biological assessment (BA) for compliance with Section 7 of the ESA to address all threatened and endangered federally-listed species associated with the Restoration Project. Biological surveys were performed to determine the existence of aquatic and terrestrial federally-listed species, and/or their habitats, within the project area. Separate biological opinions (BO) were issued by NMFS and by USFWS in June 2005 pertaining to the species under their jurisdiction, based on these surveys. An additional BO was issued by NMFS in July 2009 to provide essential fish habitat (EFH) consultation under the Magnuson-Stevens Act.

The Restoration Project will involve several Clean Water Act environmental permits. Pursuant to Section 404, Reclamation had to obtain permits from the U.S. Army Corps of Engineers (USACE) for project actions involving the placement of dredged or fill material into waters of the United States. Pursuant to Section 401, and to satisfy Section 404 permit actions, Reclamation acquired a water quality certificate from the SWRCB in December 2008. Pursuant to Section 402, Reclamation obtained a National Pollutant Discharge Elimination System (NPDES) permit from SWRCB for project actions that result in storm water discharges from construction activities that disturb five or more acres of land. Spill prevention countermeasures will be required for heavy equipment operating in and near the stream channel, including best management practices. Numerous mitigation measures were adopted to meet the various permit requirements, including an Erosion Control Plan and replacement criteria for affected vegetation.

To ensure biological effectiveness, environmental monitoring and adaptive management are important elements of the proposed Restoration Project. A Facility Monitoring Plan includes methods to monitor stream flows and facility operations, and will help determine the status of habitat improvement, fish passage, and salmonid populations following construction. An Adaptive Management Plan (AMP) will allow for changes in restoration strategies or actions as necessary to achieve the long-term goals and or biological objectives of the Project, and will be managed by USFWS and CDFG. Implementation of the AMP could result in future proposals for changes in operations and project facilities to further improve fish passage effectiveness and habitat values.
DAM REMOVALS

Dam removal was identified as the recommended restoration action in cases where the estimated costs to install, operate, and maintain a suitable fish ladder and intake screen on the dam in perpetuity exceeded the estimated cost to decommission the dam and pay the present cost for the foregone hydroelectric power. Decommissioning was defined to include dam removal, pre- and post-removal environmental studies, environmental mitigation and restoration, erosion control, revegetation, monitoring, and reporting. Designs were prepared by Reclamation for the removal of Wildcat, Coleman, and South Diversion Dams and associated facilities, and of two smaller dams on South Fork tributaries, to support the Restoration Project.

Wildcat Diversion Dam is located on the lower North Fork, 2.5 miles upstream from its confluence with the South Fork, and 2.8 miles downstream of Eagle Canyon Diversion Dam. The dam and associated facilities were constructed around 1910 within a deep gorge accessible only by foot. The dam is a masonry gravity structure with a crest length of 55 feet and a maximum height of 8 feet above streambed. An old concrete steppool structure containing a steel Alaska Steeppass fish ladder is provided near the left end of the dam, and a sluiceway with a 24-inch-diameter slide gate is provided near the right end. Streamflow diversions of up to 18 ft³/s to the Wildcat Canal through a 36-inch-diameter slide gate were suspended in August 1995, under the terms of an interim agreement with Reclamation to increase instream flows. The Wildcat Canal extends nearly two miles to its confluence with the Coleman Canal, and consists of a 24-inch-diameter steel pipeline and an excavated channel section.

Coleman Diversion Dam is located on the lower South Fork, 2.5 miles upstream from its confluence with the North Fork, and 5.4 miles downstream of Inskip Diversion Dam. The dam and associated facilities were constructed around 1910 for diversion of up to 340 ft³/s to the Coleman Canal for power generation at the Coleman Powerhouse. The dam is a masonry gravity structure with a concrete overlay, having a crest length of 88 feet and a maximum height of 13 feet above streambed. The original concrete steppool fish ladder located on the left abutment was abandoned in place and replaced by an Alaska Steeppass fish ladder near the right abutment. A 14- by 8-foot radial sluice gate is provided near the right end of the dam. Streamflow diversions to the Coleman Canal are controlled by a series of gate structures located downstream of the dam on the right abutment. The Coleman Canal extends nearly 10 miles to the Coleman Forebay and Powerhouse, and consists of excavated channel sections and a 90-inch-diameter siphon.
South Diversion Dam is located on the upper South Fork, 6.4 miles upstream of Inskip Diversion Dam. The dam and associated facilities were constructed for diversion of up to 100 ft³/s to the South Canal for power generation at the South Powerhouse, near Inskip Diversion Dam. The original timber crib dam was replaced in 1979 by a steel bin-wall gravity structure with a crest length of 155 feet and a maximum height of about 20 feet above the streambed. The 100-foot-long overflow crest includes a 17-foot-wide concrete cap beneath a welded steel plate. A steel denil-type fish ladder is attached to the downstream face of the dam below a steel deflector plate. A 12- by 8-foot radial sluice gate is provided near the right end of the dam. Streamflow diversions to the South Canal are controlled by a 60-inch-diameter slide gate at the inlet portal of a short tunnel section on the right abutment. The South Canal extends nearly 6 miles to its confluence with the Cross Country Canal, where both canals combine to form the Union Canal before entering the South Powerhouse penstock. The South Canal consists of metal flume, unlined rock tunnel, and excavated channel sections.
The dam removals will be performed during the specified instream work period for each site, which includes the historical low flow period for Battle Creek. These periods are May through August for the Wildcat and Coleman sites, and May through October for the South site. This will minimize potential impacts to the spring-run and winter-run salmon, and facilitate construction activities in the river channel. At each site, low-level releases will be made through existing sluiceways for reservoir drawdown. Upstream canal diversions will be used to the maximum possible extent to reduce streamflow at the Wildcat and Coleman sites. Site access to the Wildcat and South Diversion Dams is poor and will significantly impact removal activities. The use of a helicopter is planned for airlifting construction equipment into the Wildcat site and for removal of waste materials, due to the deep canyon setting. Improvements to an existing river crossing and trail road will be required for equipment access at the South site. Existing access to the Coleman site is by paved road to the right abutment.

Mechanical excavation methods are planned for removal of Wildcat Diversion Dam, since the use of explosives at the site could produce unacceptable environmental, safety, and upper slope stability concerns of the rimrock on the canyon walls. Using the available sluiceway and canal diversion capacities to maintain the reservoir level below the crest of the overflow section (at elevation 1074.7), and placing large sand bags and water bladders by airlift, will allow the left half of the dam to be unwatered for demolition by a Mini-Excavator and hydraulic hoe-ram. The masonry should readily break up at the mortared joints, and the masonry rubble will be spread across the downstream channel. Waste concrete, reinforcing steel, and mechanical items from the concrete steppool fish ladder will be flown out by helicopter using a large skip or bucket. Once the left half of the dam is breached, the demolition activities will move to the remaining portions of the dam, including the sluiceway and canal headworks structure. An existing stream bubble gauge and concrete apron below the dam will remain. The 24-inch-diameter steel pipeline portion of Wildcat Canal will be cut up and airlifted out in approximately 30-foot sections over much of its 5,530-foot length. Steel pipe supports, standpipes, handrails, and catwalk sections along the canal will also be airlifted out. Special care will be required to remove the pipe sections due to the presence of lead-based paint and asbestos sheets at the concrete supports. Although the majority of the concrete saddle supports on PG&E land will remain in place to reduce project costs, the concrete pipe supports on private land will be removed. The excavated channel section of the canal will be backfilled using imported material, and the site will be reseeded.

The removal of Coleman Diversion Dam will occur only after a direct connection has been completed from the Inskip Powerhouse tailrace to Coleman Canal (as described below), thus providing a large streamflow bypass capacity at the site of up to 300 ft³/s. The existing sluiceway will permit the reservoir to be drawn down below the crest of the overflow section (at elevation 1003.3), and the placement of large sand bags by crane will allow the left half of the dam to be unwatered for demolition. All concrete and masonry rubble from the dam and concrete fish ladder will be removed for disposal. After the left half of the dam is breached, the remaining portions of the dam, including the concrete sluiceway and Alaska Steeppass fish ladder, will be demolished and removed. The existing canal intake weir structure on the right abutment will be retained and backfilled.
for channel bank protection. A 500-foot-long pilot channel will be excavated upstream within the reservoir sediments to help direct the streamflow through the site. All downstream portions of Coleman Canal will remain in use, for continued water supply to Coleman Powerhouse.

Using the available sluiceway and canal diversion capacities at South Diversion Dam during the low flow period will allow the reservoir to be drawn down below the crest of the overflow section (at elevation 2027.1). Construction of an upstream cofferdam will permit the steel bin-wall gravity structure and fish ladder to be unwatered for disassembly and removal from the site. The steel plate and reinforced concrete cap will first be removed from the overflow crest by cutting into smaller sections for handling purposes. The granular backfill from the steel bins will then be removed for disposal within the stream channel, and the steel bin-wall components will be unbolted or cut apart for removal from the site. Removal of the upstream cofferdam will breach the reservoir and permit the demolition of the concrete sluiceway structure on the right abutment. If the canal intake and tunnel portal structure is retained, the slide gate will be permanently closed by welding and access to the gate operator will be eliminated for safety reasons. Many portions of South Canal are difficult to access. The metal flume sections will be disassembled and airlifted out in a manner similar to the original construction; however, some of the reinforced concrete footings along the metal flume alignment may be left in place to reduce costs. The excavated channel sections will be backfilled to the extent possible using local materials, and the existing tunnel portals along the canal alignment will be plugged with concrete or rockfill to prevent unauthorized entry.

Two smaller diversion dams on South Fork tributaries will also be removed for the Restoration Project. Soap Creek Feeder Diversion Dam is located on Soap Creek, about 1 mile above its confluence with South Fork, and provides up to 15 ft³/s to the South Canal via a 24-inch-diameter pipeline. The existing dam is a concrete gravity structure with a structural height of 10 feet and a crest length of 41 feet. A 42- by 42-inch sluice gate is provided near the left abutment, and would be used to draw the reservoir level down about 5 feet below the overflow crest for removal by blasting or hoe-ram. Lower Ripley Creek Diversion Dam is located on Ripley Creek, about 1 mile above its confluence with South Fork, and provides up to 3 ft³/s to the Inskip Canal via an open canal section. The existing dam is a 17-inch-thick concrete wall with a structural height of about 5 feet and a crest length of 44 feet. Diversion releases are made through a 22- by 35-inch wooden slide gate near the left abutment. The structure can be easily removed by mechanical methods, and the canal will be backfilled using local materials.

None of the diversion dams falls under the jurisdiction of the CDWR Division of Safety of Dams due to their small size - less than 25 feet in height, and less than 50 acre-feet of storage. Each dam is classified as a low hazard structure by FERC. Consultation was performed with the California State Historic Preservation Office (SHPO) for all properties eligible for listing in the National Historic Register, as required under Section 106 of the National Historic Preservation Act, to allow structure removal. Onsite disposal of some waste materials may be permitted to reduce project costs. The masonry materials generally consist of rounded cobbles ranging between 6 and 24 inches in size.
within a cement mortar matrix, and can be left within the stream channels provided they are distributed sufficiently to prevent ponding. Waste concrete and reinforcing steel will generally be removed from the sites for disposal, while some of the mechanical items and miscellaneous metalwork may be salvaged for use by either PG&E or CDFG. Special handling and disposal will be required for coated metal items containing lead or other heavy metals.

The small reservoirs impounded by the diversion dams are mostly filled in with sand, gravel, and cobble materials. Since significant quantities of clay, silt, or fine sand are not expected within the sediment behind the dams, there should not be a large increase in stream turbidity or other problems associated with the transport and deposition of fine material during natural erosion. The designs include the excavation of pilot channels upstream through the sediment behind Coleman and South Diversion Dams prior to their removal. Mechanical channelization will help the stream return to its pre-dam condition more quickly and with less environmental consequences than through natural erosion alone. Smaller sediment volumes are impounded by the other dams and are of lesser concern. The diversion dams to be removed impound a total sediment volume of about 63,000 yd³, which is much less than the annual sediment transport capacity of the streams, and is expected to have little effect on the downstream channel. Any increase in turbidity is expected to be of short duration due to the small quantity of fine material.

HYDROPOWER FACILITY MODIFICATIONS

Removal of South and Soap Creek Feeder Diversion Dams will eliminate streamflow diversions of up to 115 ft³/s to the South Canal, which supplies water to the South Powerhouse; however, diversions from the North Fork to the Cross Country Canal can be increased to help offset this reduction. Total flow to the South Powerhouse (with a net head of 516 feet) from both canals (via the Union Canal) will be reduced from 190 ft³/s to 155 ft³/s. Despite the removal of Lower Ripley Creek Diversion Dam, streamflow diversions to the Inskip Powerhouse (with a net head of 383 feet) will remain at 270 ft³/s due to increased diversions from the South Fork at Inskip Diversion Dam. Power generation at the Coleman Powerhouse (with a net head of 482 feet) will be limited to the 270 ft³/s flow released from the Inskip Powerhouse to Coleman Canal, since additional diversions will no longer be made at Coleman Diversion Dam. This is a reduction from the original design capacity of 340 ft³/s. The average annual generating capacity of the Hydroelectric Project will be reduced by approximately one-third as a result of the Restoration Project, or from 231.4 GWh to 162.2 GWh.

To prevent the release of colder North Fork water into South Fork above their confluence, in order to avoid false attraction of North Fork spawning fish to the South Fork (and avoid other fishery impacts due to sudden flow surges and rapid drawdowns in the stream resulting from canal outages), tailrace releases at both South and Inskip Powerhouses will be conveyed directly into the downstream canals. The construction of tailrace connectors at both sites will permit canal flows to bypass the natural stream channel entirely. The South Powerhouse tailrace connector will consist of a 1,100-foot-long unlined tunnel excavated through volcanic tuff-breccia of the Tuscan Formation.
The tunnel inlet will be located within the existing tailrace channel near the end of a narrow peninsula which currently separates the tailrace from the South Fork. Releases from both South Powerhouse and from an existing overflow wasteway channel for Union Canal will be diverted through the bypass tunnel and into Inskip Canal downstream from a new fish screen structure. The provision of a radial gate at the upstream tunnel portal, and a precast concrete box culvert from the tailrace channel to the South Fork, will permit unwatering of the tailrace for maintenance purposes and continued power generation during construction or tunnel maintenance. A new access road will be provided from South Powerhouse to the downstream tunnel portal, where a hydraulic jump stilling basin will be provided for energy dissipation of tunnel flows. All tailrace connector features will have a design discharge capacity of 165 ft³/s, which includes potential local surface runoff flows of up to 10 ft³/s into the tailrace channel. Flood protection will be provided for the open tailrace channel to contain the estimated 100-year flow in South Fork by the construction of a mechanically-stabilized earth (MSE) dike along the peninsula from South Powerhouse to the bypass tunnel portal. A precast concrete block overflow spillway will be provided at the downstream end of the dike to serve as an emergency wasteway for canal flows.

The Inskip Powerhouse tailrace connector will consist of a 654-foot-long buried pipeline from a modified tailrace structure at the powerhouse to a reinforced concrete transition structure at Coleman Canal, near the site of the Coleman Diversion Dam. A total discharge capacity of 300 ft³/s was selected for design, including potential excess diversions or local surface runoff in addition to the normal powerhouse flow. An 84-inch-diameter reinforced concrete pipe will limit flow velocities to less than 8 ft/s to minimize head loss. Slide gates will be provided at both ends of the buried pipeline for inspection and maintenance purposes.

The existing overflow wasteway for Inskip Canal (above Inskip Powerhouse) discharges directly into the South Fork through a natural gully located several hundred feet upstream of the tailrace area. This wasteway prevents overtopping damage to the canal when water flow is stopped at the forebay structure, removes excess flows when more diversion water is supplied than can be passed through the powerhouse unit or bypass valve, and handles excess water entering the canal at cross-drainages due to local surface runoff. Wasteway flows have historically been less than 30 ft³/s with a maximum duration of about a month. Higher wasteway flows due to flow rejection at the penstock may occur a few times a year for a few hours, and would interrupt canal deliveries to Coleman Powerhouse. To direct these flows into Coleman Canal, a new penstock bypass will be constructed from Eagle Canyon Canal near the Inskip Powerhouse forebay approximately 5,000 feet to Coleman Canal. The upper section is a 66-inch-diameter reinforced concrete pipeline approximately 3,600 long, and the lower section is a 72-inch-diameter reinforced concrete pipeline approximately 270 feet long, separated by an upper jump basin, chute, and lower jump basin, with a design discharge capacity of 340 ft³/s.
FISH PASSAGE FACILITIES

Final designs were prepared by CDWR at three diversion dam sites for new fish ladders, to improve upstream migration for a greater range of flows compared to the existing facilities, and for fish screens, to prevent the loss of downstream migrants to the diversion canals. The existing facilities include two different types of fish ladders: concrete pools and weirs, and metal Alaska Steeppass ladders. Although maintained by PG&E over the years, the existing fish ladders have been generally ineffective for low flows and impassable for high flows. Alternative designs were evaluated for each site considering several factors including fish passage efficiency, operation and maintenance, location and condition of existing facilities, stream characteristics and hydrology, water rights, owner liability, and biological criteria. Final design criteria for the ladders and screens conform to minimum requirements established by NMFS and CDFG for anadromous fish. All screen panels will be continuously cleaned by a sweeping-type brush apparatus and will be located in canals with design approach velocities of 0.33 and 0.40 ft/s. Monitoring of adult fish at each site by USFWS and/or CDFG will be by video cameras and automated fish counters.

Eagle Canyon Diversion Dam is located within a deep gorge on the North Fork, 2.8 miles upstream from Wildcat Diversion Dam, and provides up to 70 ft³/s to Eagle Canyon Canal for power generation at Inskip and Coleman Powerhouses. The masonry dam has a structural height of 11 feet and a crest length of 66 feet at elevation 1412.4. A new vertical slot fish ladder and flat plate fish screen structure is planned for the left abutment of the dam. The fish ladder is designed for a flow range of 20 to 70 ft³/s and will extend through an excavated notch in the existing dam. Fourteen pools with baffles containing 15-inch-wide slots will be provided. The fish screen will pass PG&E’s full (non-consumptive) water right of 70 ft³/s, and will be constructed with removable stainless steel panels within an enlarged canal section. Water surface elevations at the fish screen will be controlled by backwater from an existing downstream tunnel. A flood wall extending above the 100-year flood level will be constructed to protect the new fish facilities. Site access is provided by a narrow foot trail down the south canyon wall which is to be improved. A helicopter is expected to be used to facilitate construction and to minimize damage to the canyon walls and vegetation.

Figure 2. Proposed Eagle Canyon Diversion Dam Screen and Ladder.
North Battle Creek Feeder Diversion Dam is located 4.1 miles upstream of Eagle Canyon Diversion Dam, and provides up to 55 ft³/s to the Cross Country Canal for power generation at South, Inskip, and Coleman Powerhouses. The masonry dam has a structural height of 13 feet and a crest length of 94 feet at elevation 2091.4. A new pool and chute fish ladder is planned for the mid-section of the dam, with a new flat plate fish screen structure planned for the left abutment at the location of the existing canal headworks. The new fish ladder will have a maximum design flow capacity of 110 ft³/s, and will contain 7 resting pools between 8 baffles with weirs and orifices over a length of 69 feet. The fish screen will have fixed panels sloping 30 degrees from vertical. An 18-inch-diameter fish bypass pipe will also be provided. A new access road and footbridge will be provided to facilitate construction and future operations and maintenance.

Inskip Diversion Dam is located on the South Fork, between Coleman and South Diversion Dams, and provides up to 220 ft³/s to Inskip Canal for power generation at Inskip and Coleman Powerhouses. The masonry dam has a structural height of 28 feet and a crest length of 100 feet at elevation 1435.0. A new Half Ice Harbor (pool- and weir-type) fish ladder and a flat plate fish screen are planned for the right abutment of the dam. The existing canal headworks will be modified to accommodate two automated slide gates, and the downstream canal will be enlarged to accommodate the fish screen and provide a flow velocity of 3 ft/s. The fish ladder will be located immediately after the fish screen and will turn three times before joining the entrance pool approximately 75 feet downstream of the dam. Auxiliary water will be collected from behind the fish screen and be piped to the fish ladder entrance, where it will be diffused through a floor grating to limit the flow velocity to 1 ft/s. The design flow capacity of the new fish ladder is 39 ft³/s, with auxiliary flows up to 131 ft³/s. The fish ladder will provide 25 pools connected by weirs and orifices, with a short wingwall in each pool extending upstream to provide a resting place for upstream migrants. The water surface at the top of the ladder will be maintained by two weir gates located behind the fish screen. The

Figure 3. Proposed North Battle Creek Feeder Diversion Dam Screen and Ladder.
fish screen will be designed for the full diversion flow of 220 ft$^3$/s, with removable screen panels sloping 30 degrees from vertical. A clogged fish screen will trigger shut down of the diversion flow under “fail-safe” criteria required by the MOU.

Figure 4. Proposed Inskip Diversion Dam Screen and Ladder.

DISEASE PREVENTION FEATURES

A potential was identified during final design for the spread of water-borne pathogens (including the IHN virus) from a growing population of migrating anadromous fish in Battle Creek to locally-produced native trout within state- and privately-owned fish hatcheries. This resulted in the development of designs to replace a portion of open unlined channel along Eagle Canyon Canal with a 4,500-foot-long buried pipeline to prevent the potential contamination of the local springs and groundwater used to supply a down-slope fish hatchery owned by Mt. Lassen Trout Farms (MLTF). A second MLTF hatchery fed by Willow Springs in the vicinity of the Inskip Powerhouse penstock bypass is planned to be purchased and closed for the Project. A fish barrier weir is planned for Baldwin Creek, a tributary to the mainstem Battle Creek with a minimum flow requirement of 5 ft$^3$/s, to prevent the passage of steelhead upstream to the Darrah Springs State Fish Hatchery, which is operated by CDFG to produce trout for sport fisheries.

PROJECT FUNDING

Initial project funding in the amount of $28 million was derived in 1999 from appropriations authorized under the California Bay-Delta Environmental Enhancement Act for design, construction, environmental permitting, mitigation, and monitoring costs, to be administered by CALFED. An additional $49.25 million in state and federal funds...
was received in July 2008 from various Proposition 50 and environmental mitigation sources for implementation of Phase 1A. Phase 1B will use $26 million in funds provided by the American Recovery and Reinvestment Act (ARRA). Phase 2 funding must still be obtained. PG&E commitments for 90 percent of the present value of foregone hydroelectric power, increased operation and maintenance costs, monitoring costs, transfer of water rights at dam removal sites to CDFG for instream use, and FERC relicensing costs were established by the 1999 MOU. A Water Acquisition Fund (from federal funding) for future purchases of additional instream flow releases, and an Adaptive Management Fund (from a third party donor) for implementation of any additional project refinements, have also been established.

CONSTRUCTION CONTRACTING AND STATUS

The first construction contracts were for removal of Wildcat Diversion Dam and Canal, awarded to Contractor Services Group for $2,062,555 in September 2009, and for the North Fork Screens and Ladders (at Eagle Canyon and North Battle Creek Feeder Diversion Dams), awarded to Syblon Reid for $10,813,000 in October 2009. Additional contracts for this phase of the project (Phase 1A), which received a FERC Order in August 2009 accepting PG&E’s application for a license amendment, includes the Eagle Canyon Canal Pipeline and the Baldwin Creek Barrier Weir, planned for later in 2010. Construction for the Inskip Powerhouse tailrace connector and penstock bypass will be performed under Phase 1B, and is expected to be awarded by June 2010 using ARRA funds, pending FERC approval of the license amendment. Remaining contracts for construction of the South Powerhouse tailrace connector and Inskip Diversion Dam screen and ladder, and for removal of South, Soap Creek, Lower Ripley, and Coleman Diversion Dams, will be awarded under Phase 2 at a future date. Each contract requires selected contractor submittals to be reviewed by FERC before authorization to begin construction activities.

CONCLUSION

Restoration efforts on Battle Creek in northern California involve modification of PG&E’s Hydroelectric Project by the removal or modification of eight small diversion dams, and have the potential to restore and enhance 48 miles of fish habitat in Battle Creek and its tributaries to enable safe passage for, and the growth and recovery of naturally-produced anadromous salmonids, including three federally-listed species. Support for the Restoration Project comes from local residents, environmental organizations, PG&E, state and federal resource agencies, and various stakeholder groups. Reclamation’s roles to support the project include overall project management, development of project designs and specifications, and fulfillment of all environmental compliance requirements. Environmental compliance will be linked with project designs to minimize environmental impacts, streamline the analysis of environmental consequences, and ensure that all impacts are adequately mitigated.
REFERENCES


Memorandum of Understanding – Battle Creek Chinook Salmon and Steelhead Restoration Project, June 1999.