

EMERGENCY OUTLET GATE REPLACEMENT PROJECTS AT TWO EL DORADO IRRIGATION DISTRICT HIGH SIERRA LAKES

William Rettberg, P.E. and Jacob E. Eymann, P.E.

Introduction

By the turn of the twentieth century, with a burgeoning California population, there was an emerging need for inexpensive electrical energy. The Sierra Nevada Mountain Range furnished high elevation drops and abundant water –all these factors combined were the right recipe for the onset of hydroelectric development in the west. “By 1900 there were already 25 hydroelectric plants in service throughout the state (California)...” -Historic Resources Inventory and Evaluation Report for Lake Aloha Main Dam, JRP Historical Consulting, March 2004. The El Dorado Irrigation District (District) owns and operates one of these original hydroelectric project; the El Dorado Project 184.



Figure 1. Aerial view of Silver Lake.

This paper will present the challenges and opportunities of two emergency projects which replaced the failing 85 year-old outlets of two high Sierra dams that are part of the El Dorado Irrigation District domestic and hydroelectric system. Common to both dams, the outlets do not have upstream guard gates that can shut-off flows in order to make repairs to the control gates in the dry. Due to the outlets’ high elevations and inaccessibility, inspection and maintenance are difficult. Challenges that were overcome included emergency reservoir drawdowns; compressed design and gate procurement schedules; fish rescue and stream bypass pumping; and short-construction windows, weather, permitting, and approvals. Through proper emergency planning, design, procurement, and execution, the project challenges were met and the operation of the outlets returned to a safe and reliable condition.

Project Location & History

The El Dorado Project 184 hydroelectric system was constructed by Western States Gas and Electric Company between 1917 and 1924. The "184" in the project bears testament to its early beginning in the federal project naming. Hydraulic mining dams and canals from the 1860s were significantly enlarged and improved, as engineering technology advanced, as part of the construction of El Dorado Project. The El Dorado Project as completed in 1924 and in operation since then, consists of four storage reservoirs located in three counties all situated above 7,000 feet elevation, a diversion dam on the South Fork of the American River, 22 miles of canals, flumes, siphons, tunnels, a regulating forebay, a penstock and a 20 megawatt powerhouse developing 1,910 static feet of head. Silver and Caples Lakes are two of the four storage reservoirs and are the subject of the paper.



Figure 2. Caples Lake Main Dam during raising, 1923.



Figure 3. Silver Lake Timber Crib Dam as constructed in 1917.

Pacific Gas and Electric Company (PG&E) had supplied the District with project water, but with the electrical deregulation of the California electrical power industry and PG&E's desire to sell the El Dorado Project, the District looked to secure the water rights associated with El Dorado Project. The sale of the PG&E's El Dorado Project to the District was finalized in 1999 for a sale price of \$1. During the sale negotiations, the infamous 1997 flood inflicted significant damage to the project and as a result, PG&E paid the District \$17 million to make the necessary repairs to restore operation.



Figure 4. Caples Lake.

Caples Lake is located in Alpine County, on the Caples Creek tributary to the South Fork of the American River, 16 miles south of Lake Tahoe, California, at an elevation of 7800.9 ft above sea level. It has a gross storage capacity of 22,338 acre-feet used for hydroelectric generation, domestic water supply, stream flow releases, and recreation. Caples Lake is formed by a main and double concrete arch auxiliary dam which also serves as the spillway. The main dam is 86 feet high and 1,200 feet long with State Highway 88 on the crest. The Main dam houses the outlet works and has a concrete corewall running along its axis.

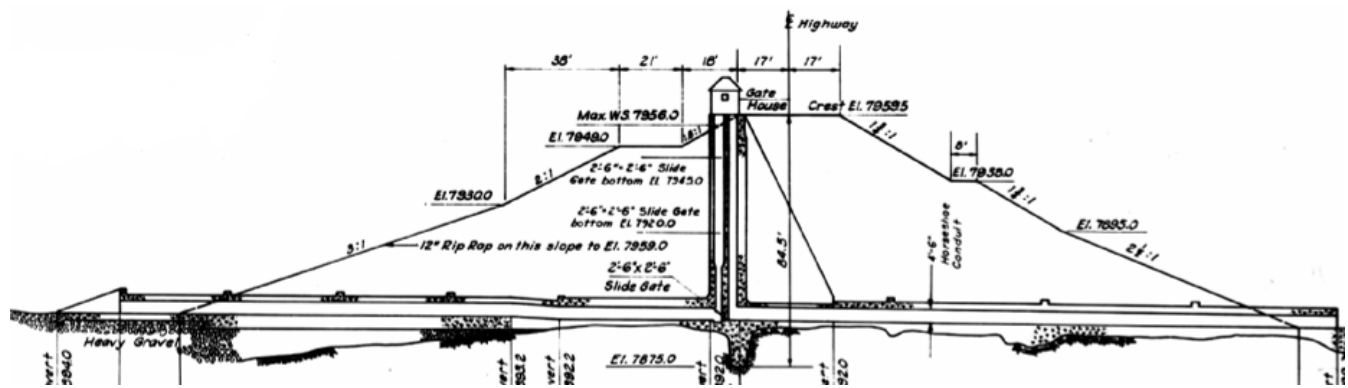


Figure 5. Caples Lake Main Dam cross-section showing gate house gate shaft, gate locations, and conveyance conduit.

Silver Lake Dam is located in Amador County, on the Silver Fork of the South Fork of the American River, 19 miles south of Lake Tahoe at an elevation of 7,265 feet above sea level. The dam is 32 feet high, and has a gross storage capacity of 8,590 acre-feet used for domestic water, hydroelectric generation, domestic water supply, stream flow releases, and recreation. The outlet works are described later in the paper.

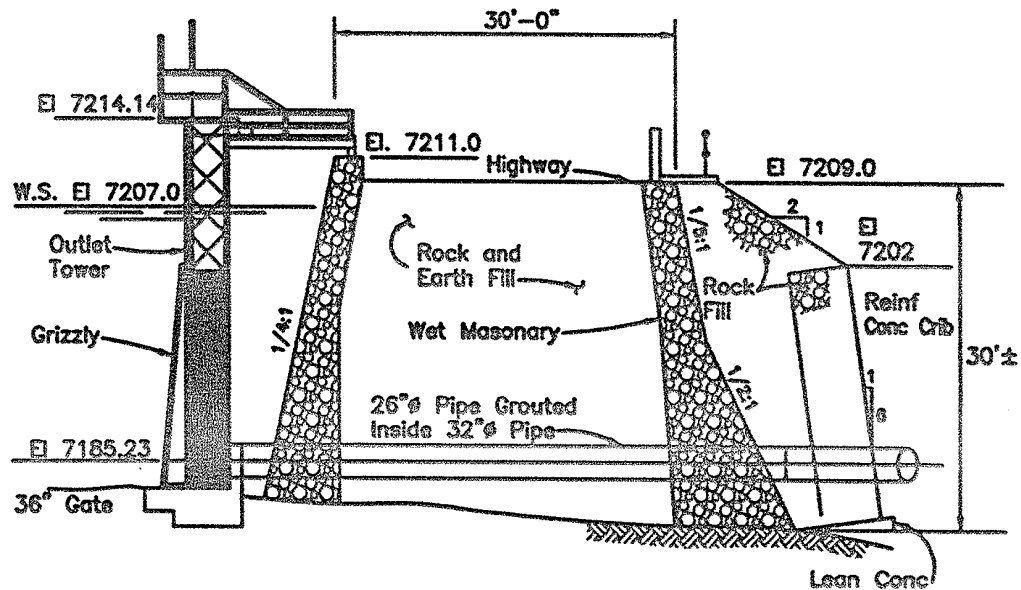


Figure 6. Silver Lake Dam cross-section showing outlet tower and gate location.

Project Identification and Emergency Declaration

In the summer of 2006, District dam operators noted some lurching and binding while operating the gates at Caples Lake while making high releases due to the higher than normal spring run-off. These operational conditions had been experienced historically, but they seemed to have increased. The District had no record of any underwater inspections conducted by the previous owner Pacific Gas and Electric Company, record drawings were in some places generalized and not reliable. Both dams were completed prior to the formation of either the California Division of Safety of Dams (DSOD) or the Federal Energy Regulatory Commission (FERC). These information voids added to the planning and engineering challenges. The District’s engineering team mobilized a District underwater remote operated camera to get a visual on the condition. The reconnaissance level inspection revealed corrosion and a few broken stem restraints, however, nothing of an emergency nature as was revealed by the later comprehensive dive inspection conducted on June 11 and 12, 2008. The underwater inspection revealed the following significant deficiencies of the Caples Lake outlet works:

- Bronze seats for the lower slide gate were missing, resulting in excessive leakage and vibration;
- The lifting connection of the lower slide gate leaf and the gate stem was degraded and loose;
- The concrete adjacent to the lower slide gate frame was heavily eroded, resulting in steel reinforcement exposure and corrosion;
- The lower gate stem was bent in two directions, which resulted in binding against the concrete shaft wall and the upper gate during gate operation;
- Several metal stem restraints required to align, guide, and prevent stem buckling were missing or broken;

- The slide gates, gate stems, and stem guides were all severely corroded, compromising their structural integrity and putting them at risk of sudden failure;
- Both gate stems were found to be installed out of plumb;
- Combined leakage from the closed slide gates was approximately 900 gallons per minute and
- The trash rack on the intake was severely bent and dislodged from its original installation.



Figure 7. Section of 70 foot long Caples outlet valve stem after removal during 2008 emergency repair (notice permanent deformation).

The Silver Lake dive inspection was conducted on June 12, 2008 not because of any noted operator concerns, but rather as a proactive approach. General superficial corrosion had been noted in the past, but not to the extent revealed by the detailed underwater diver inspection. The underwater inspection revealed the following significant deficiencies of the Silver Lake outlet works:

- The steel bracing for the outlet tower was completely failed due to corrosion;
- The other steel members had experienced significant corrosion and section loss;
- The degree of corrosion increased from top to bottom on the outlet tower;
- The valve stem was heavily corroded and pitted.



Figure 8. Silver Lake outlet tower removed during the 2008 emergency repair - Notice all of the missing sections of structural bracing leaving no bracing for the lower vertical third of the tower.

The conditions and both Silver and Caples Lake outlet were dire enough for staff to recommend that the District Board of Directors consider an emergency declaration in the interest of restoring the dams to a safe and reliable condition as soon as possible. At risk if the outlet gates were to fail were: public safety, water supply, environmental damage, regulatory violations, recreation, hydroelectric power generation, and public confidence. An emergency declaration would allow the District to quickly assemble a well-qualified engineering and construction team and expedite the permitting process. The District Board determined that the condition warranted an Emergency Declaration and on July 1, 2009, declared the emergency. The District had little time to complete the rehabilitation in 2008, as winters come early and hard in the high sierra.

Emergencies are commonly thought of as a response to a life threatening incident which has already occurred and whereby only the mitigating incident response is in view, e.g. after a fire, earthquake, or flood. An emergency declaration not only recognizes the severity of a given situation, but in these cases, is the a prime mover to quickly cut through bureaucratic processes to mobilize resources and reduce the further threat to life and property, which is not all that unlike the scenarios contemplated in this paper. But what happens in the scenario where a utility, such as the El Dorado Irrigation District, finds itself on the verge of experiencing a serious incident, but the incident has not yet occurred? Well, in a word, "fortunate", but seriously, in these cases where the incident has not occurred nor the corresponding havoc, the burden of proof weighs much more heavily upon those making such representations. Nonetheless, California state law does include both of these scenarios in

their definition of an emergency. An emergency is defined by California law as “a sudden, unexpected occurrence that poses a clear and imminent danger, requiring immediate action to prevent or mitigate the loss or impairment of life, health, property, or essential public services.” (Pub. Contract Code § 1102.) State law allows, in the case of an emergency, for an irrigation district to contract without a notice for bids if it complies with the procedures of Public Contract Code section 22050. (Pub. Contract Code § 20567). Section 15359 of the Guidelines to the California Environmental Quality Act (CEQA Guidelines, 15 Cal. Code Regs. § 15259) defines “emergency” for purposes of exempting a project from CEQA pursuant to Public Resources Code section 21080(b) and CEQA Guidelines section 15269.

In the case of the Caples and Silver Projects, the District expected that without an Emergency Declaration, they would have been a multi-year projects. It was the District’s Board’s determination that these conditions at Caples and Silver Lake Dams were in fact a sudden and unexpected occurrence, posed a clear and imminent danger, and required immediate action to prevent or mitigate the loss or impairment of life, health, property, or essential public services and therefore met the requirements for an emergency.

There was little time to lower Caples Lake in time to complete the construction in 2008 because it was July and extreme winter weather can commence in October. Large reservoirs such as Caples Lake generally take months to dewater. Accordingly, the District increased outlet discharge rates to reach the needed levels by fall. Immediately after the Emergency Declaration, the District increased the frequency of meetings with the Ecological Resources Committee (ERC) to bi-weekly in order to work through details and progress of the drawdown and to ensure ongoing recreational safety and environmental protections were maintained. The ERC includes the District, federal agencies, state agencies, and other stakeholders including local county agencies, stream interests, lake interests, recreation interests, and other local interests.

More data on the reservoir volumes and prime location for the bladder dams was needed. So while the reservoir was being drawn down, the District commissioned a bathymetry study which provided detailed and necessary lake bottom and reservoir volume information. The bathymetry study provided the information for engineers to best site the bladder dams; this ended up being was a narrow notch upstream of the Main Dam adjacent to an old bridge which once carried emigrants via wagon train into California in the 1800s prior to the construction of the dam and its inundation. The bathymetry study was also a critical piece in maximizing reservoir storage behind the bladder dams to preserve the fishery if possible (later found to have been successful for the 2008-2009 winter fishing accounts and pictures) while amply sizing the bypass pumping system to sustain aquatic life downstream of the dam by the bypass pumping system.



Figure 9. Bladder dams for the 2008 emergency repair of Caples Dam outlet



Figure 10. Bladder dams for the 2009 emergency repair of Silver Lake Dam

During the drawdown, two fish rescues were conducted in coordination with the California Department of Fish and Game. Due to concerns that a lowered reservoir may not be able to completely sustain the fisheries over the winter period, the first rescue was conducted. During this three-day netting and electro-fishing boat

operation, 6,000 fish were collected and relocated to other nearby reservoirs. A second fish rescue was conducted when the bladder dams were installed in the reservoir between the them and Caples main dam when dewatered for construction. This second rescue collected and relocated 20,000 fish to other nearby reservoirs. To ensure that the Caples fisheries would be thriving after the reservoir drawdown, the District also committed to a robust 10-year fish restocking plan, including trophy fish, to begin in late spring 2009.



Figure 11. First fish relocation for the Caples Project.



Figure 12. Second fish relocation.

Assembling the Team

Assembling the team was one of the critical elements for project success. If it takes a village to raise a child, it takes a team to build a project. It was determined that there was insufficient time and the public safety and water supply risks too great to wait for the time for traditional project processes to be completed. An

Emergency Declaration by an elected board of officials fulfills the California Environmental Quality Act requirements for an exemption and the public contracting codes requirements for Public Bidding. The emergency permitted the District to streamline the normal procurement process and obtain engineers, materials, and contractors. It should be noted that environmental protections are still required to be maintained and permits required.

GEI Consultants, already under contract for assessing the integrity of the dams and outlets, was retained for the engineering. Interviews with several qualified contractors were held to assess their experience, qualifications, and the project superintendents available to do the work. Syblon Reid Construction (SRC), Folsom, CA, rose to the top because of their specific experience with dam outlet works rehabilitation, and general top-quality service to the District during other fast-track projects. Thereafter, SRC was retained in a two-phased agreement; whereby, they were separately compensated for planning and permitting assistance during project definition and provided a bid once the construction scope was defined. Once the project was defined, the District and contractor commenced contract negotiations. The District provided overall project management and dam safety permitting and environmental permitting. Initially, team meetings were held to review alternatives, gate procurement, and permitting/construction strategies. Beginning in late June, time was of the essence. In the case of Caples Lake (crest El. 7800 ft), the lake was already in emergency drawdown which would take about 2 months to reach the target elevation and capacity for the installation of bladder dams. So the construction window for Caples was from late August through mid-October when winter would begin. In the case of Silver Lake (El. 7200 ft), it was decided that winter construction in February would be possible, since the lake would be at its minimum level and no emergency drawdown would be needed. Nevertheless, both projects would need to be "fast-tracked" in order to replace both outlets within a period of 8 months.

Alternatives Considered

During the dive inspection, in-the-wet outlet gate replacement was ruled out. The Caples Lake dam outlet gates are contained within a 65-foot vertical shaft in the crest of the main section of the dam. Lake water is conveyed through a small, horseshoe-shaped, concrete conduit from the upstream dam toe to discharge about 400 ft downstream into Caples Creek. As-built construction information was extremely sparse. One of the cryptic notes on the drawing indicated the upstream portion of the conduit was on "heavy gravels." Therefore one alternative to insert an inflatable plug to dewater the conduit was ruled out for fear that the conduit could "float" if its interior was dewatered. A second alternative was to insert an inflatable plug in the conduit immediately upstream of the central gate shaft but was ruled out as the plug would need to be inserted from the narrow vertical shaft by divers limited to 30 minutes "bottom-time" in a confined space without assurance of a complete seal. Without this assurance, the safety of the workers in the gate shaft would be questionable. In fact, OSHA safety rules require double protection with a bleed-space for workers in potential inundation areas. Earthen cofferdams not feasible due to the deep draft reservoir, corresponding lengthy construction time, environmental concerns of cofferdam construction, uncertain environmental benefit for increased temporary reservoir storage, and high costs. The Caples alternative analysis indicated that a reservoir drawdown to 6 ft (~1000 acre-feet) would be the safest, most expeditious, most environmentally sound, and most practical option for safety and

practicality to accomplish the work. Therefore, inflatable bladder dams were chosen to retain the reservoir during construction. A site within the reservoir was located by bathymetric survey where the bladder dams could be located; however, this would require a 3,200 ft long pumping line to maintain required minimum streamflow at all time during outlet gate replacement. Even the pump-around was challenging since the dam crest was also a roadway for CA Highway 88, a major road between the Central Valley and Lake Tahoe. Fortunately, a dual drainage culvert was located so that the diversion line would not interfere with traffic. Finally, access to the outlet wet well shaft would require a lane closure for duration of construction. The Contract elected to use a dewatered bench on the upstream slope of the dam as a work platform and staging area to limit road closures.

The next significant issue faced was the selection and procurement of the gates. The original gates had cast-iron leaves with bronze seals. Replacement in-kind with cast iron gates was considered until it was learned that production schedules would be lengthy and would not fit the required construction schedule. After contacting a number of gate suppliers, the choice of fabricated stainless steel gates was the selected option. However, fitting up stainless steel gates into the existing openings in the concrete breast wall was uncertain. Therefore, the gates were ordered with stainless steel thimbles to assure proper fit and sealing. This requirement necessitated enlarging the gate openings in the concrete to fit the thimbles.

In the case of Silver Lake, the outlet tower is located near the crest of the dam in about 25 ft of water. Since the tower steel was heavily corroded, alternatives were limited to complete removal and replacement. Because this work was scheduled during the height of the winter, the decision to prefabricate the tower was necessary to speed erection time. Again, lack of reliable as-built drawings required assuming foundation conditions and how the new gate would be aligned with the existing outlet piping penetrating the dam. It was decided to fabricate a steel transition piece to marry the exiting piping with the new tower and gate. Because the work would be done in February when the reservoir would be at its lowest annual level, the decision to use inflatable bladder dams was made. The Contractor would need to clear snow and break ice to place the bladder dams, as well as, maintain streamflow diversion lines during extreme snow and subzero temperature conditions at all times.

Silver Lake is annually drawn down as part of normal operations. The reservoir level during the annual low period is sufficiently low to install bladder dams to dewater the site. The only problem is that this annual low occurs generally in late winter and just prior to the spring run-off period. This meant that the most we could allot was between 3 and 6 weeks to get in and out of the reservoir bottom. Once the spring run-off was to begin, inflows to the reservoir would overwhelm the capacity of the bypass pumps and quickly overtop the bladder dams resulting in construction site evacuation and an incomplete construction. Another schedule option would have been to delay to the next fall; however, this would have meant being exposed to the risk of another season of dam operations with an unstable tower and another reservoir drawdown.

While an emergency declaration expedited the contracting processes and satisfied CEQA requirements, none of the specific agency permits are waived. The District obtained DSOD approvals, FERC approvals, DF&G 1600, Army Corp of Engineers 404 permit, State Water Resources Control Board 401, State Office of Historic Preservation, and U.S. Forest Service Water Quality Program approval. Planning, design, permitting, contracting, and construction, and were all on concurrent paths in these emergencies. Under the traditional non-emergency

scenarios, these would be sequenced steps in a process, one following another. This compression highlighted the need for accurate upfront knowledge only attainable by having experienced leaders on the team.

Engineering, permitting, procurement, and approvals

The critical path passed through getting the gates and associated hardware specified, ordered, and delivered. Engineering the gate replacement hinged upon the gates and the installation condition and permits needed to be obtained in a timely manner from a host of state and federal agencies.

Gate procurement was expedited by the District's Emergency Declaration, which permitted obtaining quotes from suppliers and selection without a lengthy bid process. Golden Harvest, Inc. (GHI) of Burlington, Washington was selected to provide the stainless steel, fabricated gates and thimbles because of their reputation, references, and ability to expedite the delivery of the gates. The gates were ordered in early August and were on site by mid September, with a shop inspection scheduled prior to shipping. GEI worked closely with GHI during design to marry the gates up with the design of replacement including locating the stems and wall brackets in the wet well with the new operators in the control building.

At the same time as the engineering and gate fabrication was proceeding, the District's environmental staff worked closely with the engineer and contractor to define the project construction to clearly deal with expected environmental impacts and obtain permits. The project team met weekly to hone the environmental documentation to anticipate and mitigate all foreseen conditions and have alternatives, if conditions differed from those expected. Both projects required permits from more than seven (7) state and federal agencies, including dam safety modifications from the FERC and CA Division Safety of Dams. During the permitting process, it seemed like a marathon race to see if all the myriad of conditions and permits would be obtained in time for construction. As discussed later in this paper, even though this was an emergency outlet replacement project, the agencies do not necessarily have expedited permitting, and negotiation is required to get necessary reports, plans, specs, and other documentation and revisions rapidly. Contractor mobilization and site preparation were underway before some of the final permits and approvals were obtained.

Project Implementation

Caples Lake

The Caples Lake project became a race to reach the target reservoir level because as the lake level decreased, the flow rate decreased. Both the mid-and upper-level gates were opened to make the required streamflow. Maximum streamflow was limited because of downstream campgrounds. At one time, it was feared that there was a blockage of the outlet conduit; however, the lake level steadily decreased to the target elevation in early September. Bladder dams were fabricated and installed at the selected location with a primary dam, a secondary backer dam, and a third dam immediately in front of the outlet conduit inlet. Water was evacuated and the outlet system was finally dewatered. The contractor removed the roof of the control building and set electric boatswain chairs over the gate wet well and the air well for inspection and construction purposes. The gate stems and wall brackets were confirmed to be bent, misaligned, and broken. Following inspection, the gates, stems, and wall brackets were removed. Critical measurements were made in an effort to "as-built" the gate shaft for fitting the replacement gates, thimbles, stems, and wall brackets. Due to the small gate shaft space, the

alignment of the gate thimbles, gates, and stems were critical to project success. At the same time, the existing gate openings in the breast wall were being enlarged, the outlet conduit was inspected. Concrete cores were obtained in the invert which confirmed that while most of the conduit was on rock, the upstream and downstream ends were on gravels. Once the gate thimbles were properly aligned, concrete backfill and grouting was done to assure intimate connection to the concrete breast wall. Following concrete curing, the gate stems were set and aligned, and manual operators set in the control building. After a final inspection, a new trashrack was set in the intake and the bladder dams removed returning lake control to the lower gate. The lower gate was inspected to confirm it was properly sealed before the gate was operated to make the required streamflow releases before the diversion pumps were shut off and the piping removed. As the project was being completed in late October, the temperature began to fall and snow followed.



Figure 13. Working within 68 ft. deep, tapering, cramped gate wet well shaft.



Figure 14. Enlarging concrete breast-wall for gate thimble.

Silver Lake

The Silver Lake project implementation began immediately following the Caples Lake project in early November. The schedule called for engineering, gate procurement, permitting, and approval during November, December, and January to allow for construction in February. The same project delivery team repeated the process. GHI was again selected to provide the single gate, stem, stem guides, and operator. The gate was ordered in late December and delivered in early February, in spite of record snows in Washington that shut down the plant for a number of days. At the same time, the replacement tower was designed, and ordered before any approvals were obtained. The plan was to deliver the gate and its transition pipe to a metal fabricator in Nevada City, CA for fit up and alignment checks before trucking to the lake site. The contractor mobilized in early February and positioned the bladder dams, set the streamflow diversion system, and dewatered the site. Before any teardown, the tower foundation was cleared of debris and inspected. Contrary to the as-built drawings, the tower legs rested upon a relatively thin concrete mud-slab on rock. Fortunately, the design for the connection to the tower had anticipated varying conditions so “plan B” was initiated. The original tower was removed and 12-inch diameter piers were drilled into rock, and prefabricated stub angles imbedded. After concrete curing, the tower was elected to rest upon a new concrete slab bolted to the stub angles. Prior to setting the tower, the contractor erected a heated temporary shelter over the outlet pipe and transition area to allow for welding and concreting out of the weather. Once the tower foundation was ready and the pipe transition was welded and tested, the tower was erected as a single structure and the new gate fitted up. Then a short walkway was erected to connect the outlet tower to dam crest. Gate leakage was observed to be zero before returning the lake to outlet control.

The combined Caples Lake and Silver Lake emergency construction projects cost the District 3 million dollars, but were completed without any contract cost change orders or environmental violations. Both reservoirs refilled in the spring runoff in 2009 due to snow melt and rainfall and reservoir operations have returned to normal.



Figure 15. Construction site during 2009 emergency repair of Silver during good weather



Figure 16. Completed Silver Lake emergency tower and gate replacement

Lessons Learned

There were many lessons learned on these emergency outlet replacement projects as listed below:

Although inspection programs may be expensive and resource intensive, they are critical to detecting hidden problems and to maintaining facilities in good working condition.

In the event of an emergency project it is better to take a deep breath and plan, plan, and plan, i.e., to consider the range of options and develop a strong project definition that pays attention to the interplay of engineering, permitting, and construction.

Assemble a strong, project delivery team of managers, engineers, permitting specialists, and construction skills to fast-track the project.

Remember that regulators have some adjustments to make to accommodate emergency projects on fast-track projects and can resist the urgency of the project.

Select gate suppliers who are dedicated to customer service and will do whatever it takes to meet the schedule without compromising quality.

Pay attention to as-built drawings and conditions early on in the project scoping phase which may discover hazards in certain dewatering options and allow for safer alternatives to be developed.

The challenges and opportunities of improving old dams and submerged outlet systems can be daunting and costly. However, the benefit of restoring a dam safety and increasing reliability make the challenges worthwhile.

A dedicated project delivery team is important to fast-track planning, procurement, design, permitting, approvals, and construction.