

KLAMATH RIVER RENEWAL PROJECT

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ABSTRACT

The Klamath River Renewal Project (KRRP) involved the removal of four hydroelectric facilities on the Klamath River in southern Oregon and northern California, USA, to restore natural flow and volitional fish passage through the dam and reservoir reaches. This is the largest dam removal project to date in the USA. Key environmental and dam safety objectives and constraints for the dam removal works included the following: 1) reservoirs needed to be substantially drawn down (drained) during the winter season prior to dam removal; 2) reservoir drawdown rates needed to address the potential for instability of embankment dam slopes; 3) embankment dams had to be removed during the summer season when the risk of overtopping by flood flows was lowest; and 4) the final cofferdam breach at the largest, most downstream dam had to be engineered and timed to limit the peak discharge rate resulting from the release of water in the lower part of the reservoir. Dam removals were completed by October 2024, in time for the fall salmon run. Salmon were observed to have migrated upstream past the uppermost former dam site within weeks of the dam removal works being completed. Restoration and revegetation activities in the former reservoir reaches are ongoing.

RÉSUMÉ

Le projet de renouvellement de la rivière Klamath implique le démantèlement de quatre installations hydroélectriques sur la rivière Klamath dans le sud de l'Oregon et le nord de la Californie, États-Unis, afin de restaurer un écoulement naturel et de permettre le passage de gré des poissons à travers les étendues de barrage et de réservoir. Il s'agit du plus grand projet de démantèlement de barrages à ce jour aux États-Unis. Les principaux objectifs et contraintes pour les travaux de démantèlement des barrages comprenaient les éléments suivants: 1) les réservoirs devaient être fortement rabattues (vidangées) pendant la saison hivernale; 2) les réservoirs devaient être rabattues à un rythme limitant le potentiel d'instabilité des pentes des barrages en remblai; 3) les barrages en remblai devaient être démantelés pendant la saison estivale lorsque le risque de débordement était le plus faible; et 4) la brèche finale du plus grand barrage, situé en aval devait être conçue et planifiée pour éviter une vague de crue de taille inacceptable provoquée par la libération de l'eau résiduelle dans la partie inférieure du réservoir. Le démantèlement des barrages a été achevé en octobre 2024, à temps pour la montée des saumons d'automne. Des saumons ont été observés ayant migré en amont jusqu'à l'emplacement de l'ancien barrage le plus en amont à la fin d'octobre. Les activités de restauration et de re-végétalisation dans les anciennes zones de réservoir sont en cours.

1 INTRODUCTION

The Klamath River Renewal Project (KRRP) involved the removal of four hydroelectric facilities on the Klamath River in southern Oregon and northern California, USA, to restore natural flow and volitional fish passage through the dam and reservoir reaches. This is the largest dam removal and river restoration project to date in the USA.

Knight Piésold (KP) was the lead designer for the prime contractor Kiewit under a progressive design-build contract with the owner Klamath River Renewal Corporation (KRRC), developing innovative designs for the safe decommissioning of four hydroelectric dams (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate), including construction access, reservoir drawdown via new or refurbished low-level outlets, staged removal of dams and ancillary facilities, on-site material disposal, and erosion protection for the restored river channel through the former dam sites.

Key environmental and dam safety objectives and constraints for the dam removal works included the following:

- Reservoirs needed to be substantially drawn down (drained) during the winter season (January to March), in advance of the dam removals, to temporally focus and thereby minimize the impacts of reservoir sediment release on downstream aquatic resources.
- Reservoirs needed to be drawn down at a rate that addressed the potential for instability of embankment dam slopes.
- Embankment dams needed to be removed during the summer season when the risk of peak flow events and consequent overtopping of partially deconstructed embankments was lowest.
- The final cofferdam breach at the largest, most downstream dam (Iron Gate Dam) had to be engineered and timed to limit the peak discharge rate and avoid an unacceptably large flood wave resulting from the release of the residual water body in the lower part of the reservoir.

The dam removal works were successfully completed in October 2024, in time for the fall salmon run. This paper provides an overview of the project and sets the stage for a series of related papers on reservoir drawdown outlet design, modelling of reservoir water levels during drawdown, and the final cofferdam breach at Iron Gate Dam.

2 BACKGROUND

The Klamath River originates at the outlet of Upper Klamath Lake, located on a plateau in southern Oregon, and flows approximately 250 miles (400 km) southwest through the Cascade Mountains of southern Oregon and northern California to the Pacific Ocean, as shown on Figure 1. The normal annual pattern of runoff in the Klamath River basin is characterized by high flows in the spring due to mountain snowmelt, low flows in the summer and early autumn due to dry weather conditions, and increasing runoff in the late autumn and winter due to rainfall in lower elevation areas. Alterations to the natural hydrologic system began in the late 1800s, accelerating in the early 1900s, including water diversions by private water users, water diversions by and to the United States Bureau of Reclamation's (USBR) Klamath Irrigation Project, located on the plateau in the upper part of the basin in the vicinity of Klamath Falls, Oregon, and by hydroelectric developments operated by PacifiCorp in canyon sections of the river downstream from the plateau (AECOM et al, 2018).

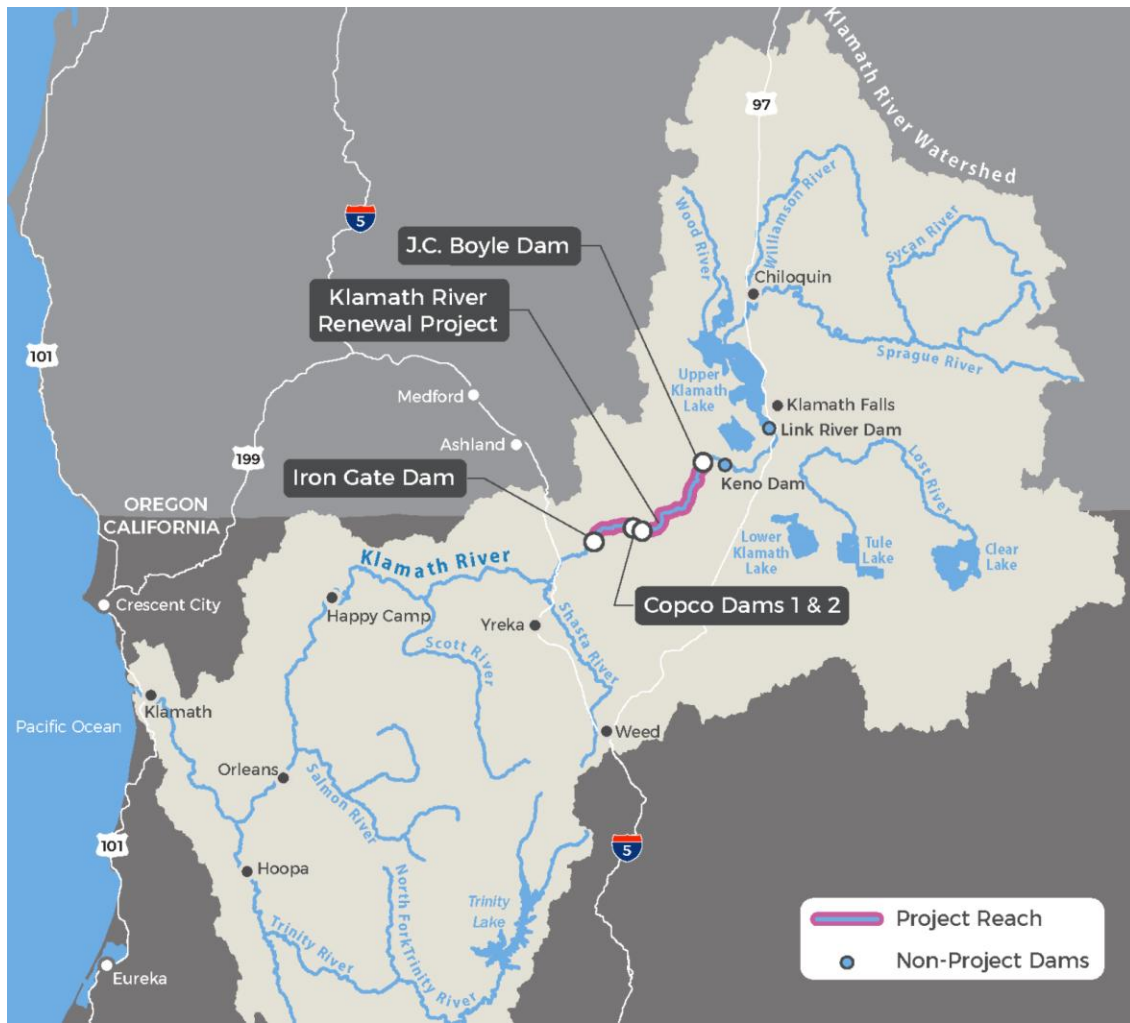


Figure 1: Project Location Map (courtesy KRRC)

The Klamath Hydroelectric Project (KHP) (FERC No. 2082) was constructed between 1911 and 1962. The KHP included eight developments: East Side, West Side, Keno (non-generating), J.C. Boyle, Copco No. 1, Copco No. 2, Fall Creek, and Iron Gate. PacifiCorp operated the KHP under a 50-year license issued by the Federal Energy Regulatory Commission (FERC), until the license expired in 2006 (AECOM et al, 2018).

Re-licensing the KHP would have entailed expensive upgrades to comply with federal water quality and fish passage regulations. Instead, PacifiCorp decided to work with stakeholders on an agreement to remove four of the developments (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate), under mutually beneficial terms that provided cost protections and certainty for PacifiCorp customers and increased access to native salmon and steelhead spawning habitat in the upper reaches of the Klamath River and to improve water quality in the lower stretches of the river. The Klamath Hydroelectric Settlement Agreement (KHSa), as amended in 2016, provides for decommissioning of the four hydroelectric dams through the FERC approval process. It also called for the creation of a new, independent non-profit entity to assume ownership of the dams and undergo the FERC and related regulatory processes to decommission and remove them. The Klamath River Renewal Corporation, or KRRC, is the organization that was created to fulfill that purpose. KRRC is part of a cooperative effort to re-establish the natural vitality of the Klamath River so that it can

support all communities in the Basin. Signatories of the amended KHSA, including the States of California and Oregon, local governments, Tribal nations, former dam owner PacifiCorp, irrigators, and several conservation and fishing groups, appointed KRRC to take ownership and oversee removal of the four hydroelectric developments (KRRC, 2025). The transfer of ownership of the four hydroelectric facilities (collectively known as the Lower Klamath Project, FERC 14803) to KRRC, and the subsequent removal of the developments, was approved by FERC.

The four former hydroelectric facilities are described below in order from upstream to downstream, and their locations are shown on Figure 1. Copco No. 1 and Copco No. 2 were constructed in 1918 and 1925, respectively. J.C. Boyle and Iron Gate were constructed approximately four decades later in 1958 and 1962, respectively.

- J.C. Boyle (Oregon): 68 ft (21 m) high earthfill embankment diversion dam with a 3 mile (5 km) long water conveyance system leading to the powerhouse, comprised of concrete canal, tunnel, and high-pressure penstock sections.
- Copco No. 1 (California): 126 ft (38 m) high concrete arch dam with powerhouse situated at the downstream toe of the dam.
- Copco No. 2 (California): 33 ft (10 m) high concrete gravity diversion dam with a 2 mile (3 km) long water conveyance system leading to the powerhouse, comprised of two tunnels, low-pressure penstock and high-pressure penstock sections.
- Iron Gate (California): 173 ft (53 m) high earthfill embankment dam with powerhouse situated at the downstream toe of the dam.

In 2019, KRRC engaged Kiewit Infrastructure West Co. (Kiewit) as its dam removal contractor. Knight Piésold (KP) served as Kiewit's lead engineering designer, with support from GeoServ, Inc., Northwest Hydraulic Consultants, Inc., and SWPP Queen, Inc. Construction planning and design took place in 2019 and 2020, followed by FERC regulatory approvals in 2021 and 2022. The final issued for construction (IFC) designs were issued in 2022 (KP, 2022). Preparatory construction activities took place in 2023, including construction access and preparation of reservoir drawdown outlets. Additionally, the smallest of the four dams (Copco No. 2) was removed in 2023 by temporarily shutting off river outflow from the Copco No. 1 dam located immediately upstream. Reservoir drawdowns at the other three developments took place in January 2024, followed by dam and infrastructure removal throughout the spring and summer of 2024. Dam removals were completed by October 2024, in time for the fall salmon run. Salmon were observed to have migrated upstream past the uppermost former dam site (J.C. Boyle) within weeks of the dam removal works being completed. Restoration and revegetation activities in the former reservoir reaches have commenced and are ongoing by KRRC.

3 RESERVOIR DRAWDOWN OUTLETS

3.1 Overview

The three facilities with significant reservoirs were required to have their water bodies substantially drawn down (drained) during the winter season (January through March) to meet environmental objectives related to the initial pulse of sediment release from the reservoirs. The fourth facility, Copco No. 2, had only a small headwater pond rather than a reservoir, and it was located immediately downstream of the Copco No. 1 powerhouse.

J.C. Boyle, Copco No. 1, and Iron Gate Dams had historic river diversion conduits in place which had been used to bypass river flows during dam construction. These diversion conduits were assessed for use as reservoir drawdown (drainage) outlets for the dam removal project. At J.C. Boyle and Iron Gate, it was

determined that the historic diversion conduits could be used to draw the reservoirs down. At Copco No. 1, it was not feasible to use the historic diversion conduit. Instead, a new low-level outlet was designed and constructed through the concrete dam.

The installation of control gates was considered for the Copco No.1 and Iron Gate drawdown outlets to regulate the rate of outflow and drawdown in these larger reservoirs under varying inflow and water level conditions to meet environmental and dam safety objectives. However, control gates were found to be infeasible and outlets with fixed orifice dimensions were constructed instead. Their drawdown performance was assessed relative to the environmental and dam safety objectives under a range of potential inflow conditions. Stage-discharge rating curves were developed using computational fluid dynamics (CFD) modelling.

The drawdown outlets for each of the three facilities is described below. The assessment of drawdown performance is discussed in Section 4.

3.2 *J.C. Boyle*

At J.C. Boyle, the historic diversion conduits consisted of a pair of concrete box culverts that had been filled with concrete following the completion of dam construction. The culvert outlets remained accessible and could be fitted with explosives to reopen them for reservoir drainage purposes. Photos of the J.C. Boyle dam and outlets are shown on Figures 2 and 3, respectively.

3.3 *Copco No. 1*

At Copco No. 1, the historic diversion conduit consisted of a diversion tunnel constructed in bedrock on the left bank of the river. The tunnel remained accessible at the outlet. A concrete plug was located midway up the tunnel. The tunnel inlet and gate structure were buried in sediment underwater in the reservoir at the base of a steep slope. Reopening the tunnel for use in draining the reservoir was determined to be impractical due to the difficulty in accessing the tunnel inlet, concerns with tunnel stability due to high flow velocities and pressures during drawdown, and alignment of the tunnel outlet which would direct high velocity flows toward the right bank of the river and the powerhouse during the initial phase of reservoir drawdown.

As an alternative approach, a new low-level outlet was designed and constructed through the concrete dam. This involved incrementally blasting and removing debris from the downstream side of the dam to create an adit, leaving a 10 ft (3 m) plug at the upstream face to be opened in a final lake tap blast to initiate drawdown. Further details about this low-level outlet are presented in an accompanying paper (Otis and Capucão, 2025). Photos of Copco No. 1 dam and historic diversion tunnel, and the low-level outlet being constructed, are shown on Figures 4 and 5, respectively.



Figure 2: J.C. Boyle Dam, looking upstream (courtesy AECOM et al, 2018)



Figure 3: J.C. Boyle historic diversion culverts, prior to opening for drawdown initiation, January 2024



Figure 4: Copco No. 1 Dam and historic diversion tunnel, looking upstream



Figure 5: Copco No. 1 Dam with low-level outlet under construction, November 2023

3.4 *Iron Gate*

At Iron Gate, the historic diversion conduit consisted of a diversion tunnel constructed in bedrock on the right bank of the river. The tunnel remained accessible at the outlet up as far as a steel gate located partway up the tunnel. The tunnel inlet and gate structure were underwater in the reservoir at the base of a steep slope, but were not fully buried in sediment. The diversion tunnel gate had been partially opened on occasion since dam construction was completed, and a 2007 tunnel improvement project had been implemented. Therefore, the tunnel was deemed to be feasible for use in drawing down the reservoir. A venting system and energy dissipation baffles were designed and constructed in the tunnel to prevent adverse hydraulic conditions, negative pressures, or bedrock erosion in the tunnel during the passage of high-head flows through the tunnel during drawdown. Further details about diversion tunnel modifications are presented in an accompanying paper (Capucao and Wechselberger, 2025). Photos of Iron Gate dam and the historic diversion tunnel modifications are shown on Figures 6 and 7, respectively.



Figure 6: Iron Gate Dam, looking upstream



Figure 7: Iron Gate diversion tunnel – energy dissipation baffles under construction, December 2023

4 RESERVOIR WATER LEVELS DURING DRAWDOWN AND DAM REMOVAL

4.1 *Overview*

The project's environmental impact analyses determined that all dams, other than Copco No. 2 which did not impound a significant reservoir, should be removed in the same year and that the reservoirs should be substantially drawn down (drained) during the preceding winter season to temporally focus sediment flushing during the season with the least potential impact to downstream aquatic species (AECOM et al, 2018). For dam safety reasons, reservoir drawdown rates for the two earthfill embankment dams (J.C. Boyle and Iron Gate) had to take into consideration the potential for instability on the dam slopes, and removal of the embankment dams had to be performed during the low-flow summer season to minimize the risk of overtopping by flood flows during removal. The numerical modelling and analyses undertaken during the design phase to assess predicted reservoir water levels against these objectives are described below and in more detail in an accompanying paper (Bennett et al., 2025). In the actual drawdown and dam removal year (2024), the KRRP team was able to coordinate with the USBR to evaluate the specific hydrologic conditions of that year and to use USBR's intended flow schedule to revise the dam removal schedule for the embankment dams. The 2024 conditions and coordination process are described below and in more detail in Bennett et al. (2025).

4.2 *Design Phase Drawdown Modelling and Analysis*

During the design phase, a numerical drawdown model was set up to simulate reservoir water surface levels under a range of variable inflows during drawdown and dam removal activities to provide a basis for assessing drawdown performance against the environmental and dam slope stability objectives. In the model, 36 years of river flow record representing a range of hydrological conditions were routed through the KRRP facilities, from J.C. Boyle to Iron Gate, with flow passing through the dams via the designed drawdown outlets according to the modelled stage-discharge rating curves. Reservoir water surface levels were simulated from the start of January, immediately prior to drawdown initiation, through until the final breach of the Iron Gate cofferdam in the late summer, after which time the Klamath River would be free-flowing through the four former dam sites.

Using the same 36 years of river flow record, flood frequency analyses were performed for each calendar month, and in some cases for semi-monthly periods for greater temporal refinement. The Project criteria for removal of the earthfill embankment dams was that the crest elevations had to remain at least 3 ft (0.9 m) above the reservoir level required to pass the 1% probable flood flow at any given time of year. The applicable 1% probable reservoir water surface elevations were obtained from stage-discharge rating curves developed for each drawdown outlet and the 3 ft (0.9 m) freeboard allowance was added to generate a monthly / semi-monthly time series of minimum crest elevations during embankment lowering.

The 36 years of simulated water surface levels and the 1% probable flood levels for Iron Gate reservoir are shown on Figure 8. The assessment of environmental and dam safety objectives is described below. Similar assessments were performed for J.C. Boyle but are not reported here.

The simulated Iron Gate reservoir water surface levels shown on Figure 8 exhibit a wide range of patterns. In most years, the reservoir level was simulated to drop to a low level within the specified January to March season, satisfying the sediment flushing objective, but in a few years modelled reservoir levels remained high until later in the spring. In most years, the reservoir was modelled to partially or completely refill at various times throughout the winter or spring, which would not contravene the sediment flushing objective, so long as the reservoir was drawn down at least once before the end of March. Overall, the drawdown

model demonstrated that the low-level outlet planned for use in lowering Iron Gate reservoir would satisfy the environmental sediment flushing objectives under most inflow scenarios and was deemed acceptable for implementation.

The modelled drawdown rates in Iron Gate reservoir (i.e. temporal rate of change of water surface levels) were used in an analysis of embankment slope stability during the drawdown operation. Dam material parameters were estimated from dam design and construction documents. No updated information was available on the dam materials to account for sediment ingress or other changes over the passage of time since dam construction. Sensitivity analyses were performed to evaluate the potential range of stability conditions associated with ranges of dam material properties. Overall, it was assessed that the most rapid drawdown rates predicted by the drawdown model would not result in dam slope stability departing from the acceptable factor of safety.

The time series of 1% probable flood levels and corresponding minimum dam crest elevations were calculated to be above the spillway crest elevation from January through until the middle of June, indicating that flood levels during this period would result in reservoir spill via the spillway and dam crest lowering could not proceed below the spillway crest elevation. From the middle of June onward, the minimum dam crest elevations dropped progressively farther below the spillway crest through the summer, reaching their lowest elevation from the middle of July to the end of August. The remnant of the dam when taken down to this elevation is termed the extended cofferdam. The dam crest would remain at this elevation until preparation of the final engineered cofferdam breach. The 1% probable flood level was modelled to increase from September onward, indicating that the final breach should be executed by the end of August, or in September subject to specific flow forecasting and USBR flow coordination to avoid an unintended breach prior to execution of the engineered breach.

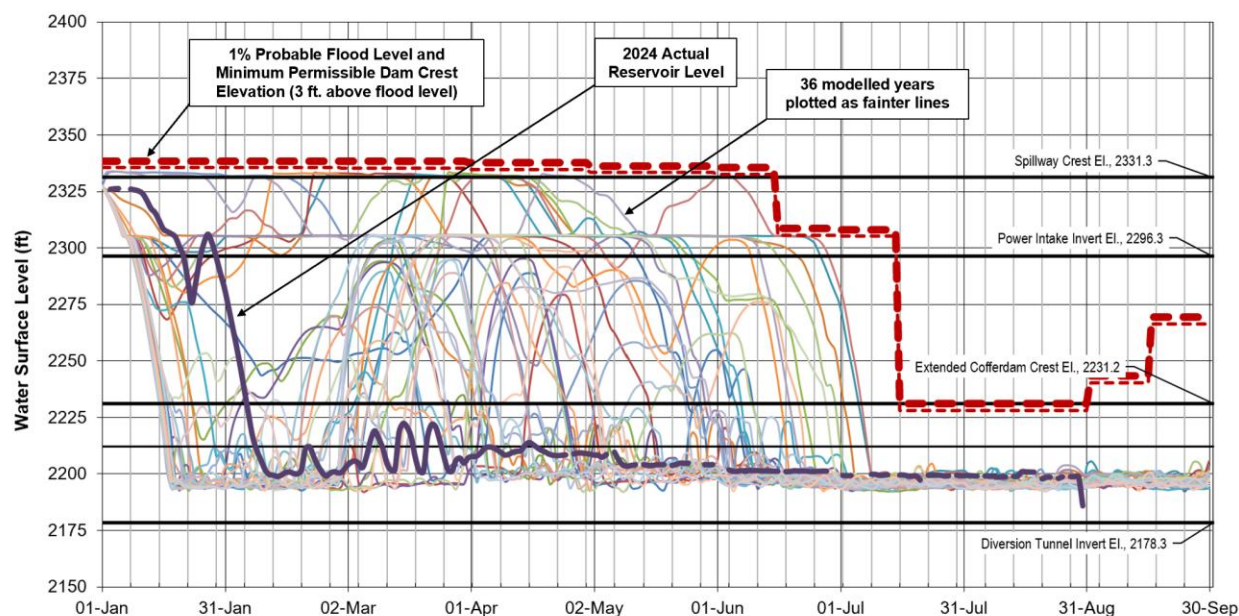


Figure 8: Iron Gate Reservoir – Actual and Modelled Water Surface Levels

4.3 *Actual Drawdown*

The drawdown of Iron Gate reservoir was initiated on January 9, 2024, when the penstock headgate was closed and the historic diversion tunnel gate was simultaneously opened to 12 inches (30 cm). The gate was progressively opened to its full 57 inch (145 cm) opening over a period of two weeks, to keep the drawdown rate at approximately 5 ft (1.5 m) per day during that period. Iron Gate reservoir was fully drawn down approximately one month later (February 11).

The J.C. Boyle low-level outlet was blasted open on January 16. Its small reservoir drained in approximately one day. Copco No. 1 reservoir was still in place at the time and it absorbed the inflow with no detectable pulse at Iron Gate reservoir. The newly constructed low-level outlet at Copco No. 1 was blasted open on January 23. Its reservoir drained over the course of four days and created a noticeable rise in the Iron Gate reservoir water level, thereby increasing the duration of its drawdown.

The actual water levels in Iron Gate reservoir are compared to the modelled levels and 1% probable flood levels on Figure 8. In general, the water levels in Iron Gate reservoir decreased at a variable rate due to variable gate openings and decreasing head driving flow through the outlet in the first two weeks, until January 23 when the pulse of water from Copco No. 1 reservoir arrived. After that, the reservoir level dropped to the fully drawn down state by February 11, thereby achieving the objective for initial sediment flushing. The actual drawdown rate closely approximated the modelled rate and no instability was observed in the daily dam slopes monitoring program.

The Iron Gate reservoir did not substantially refill after the initial drawdown, apart from a small rise due to a rainstorm in late February and three weekly flow releases from the upper basin in March, provided by USBR at KRRC's request to assist with sediment flushing. The sustained low level of Iron Gate reservoir throughout the winter and spring of 2024 differed markedly from the modelled conditions and is attributed to lower than average flow releases from the upper basin throughout the year. It was not a drought year. Cumulative water-year precipitation and snowpack were near median conditions in April 2024. However, through the combination of antecedent conditions and within-year storage management and irrigation water provision, the USBR was able to maintain flow releases from the upper basin near the minimum levels required to meet environmental regulations downstream of Iron Gate dam, which provided beneficial conditions for the dam removal project.

In April 2024, USBR was able to forecast its flow releases with sufficient certainty for KP to revise the time series of minimum dam crest elevations for Iron Gate dam. The USBR's scheduled flow releases were used to represent outflows from the upper basin, to which were added the estimated 1% probable inflow for peak flow events in the Klamath River tributaries entering the river downstream of the USBR's point of control (Keno Dam), plus 3 ft (0.9 m) of freeboard, to generate a revised set of minimum dam crest elevations. The revised crest elevations showed that the dam crest could be taken below the spillway crest elevation starting at the middle of May (one month earlier than indicated by the flood frequency analysis) and could be taken down to the extended cofferdam elevation at the middle of June (also one month earlier than indicated by the flood frequency analysis). This allowed the dam removal team to begin dam removal earlier in the season than previously planned, and to successfully complete the final breach of the extended cofferdam before the end of August, thereby avoiding the risk associated with fall rainstorms and potential overtopping of the cofferdam had the work extended into the fall season.

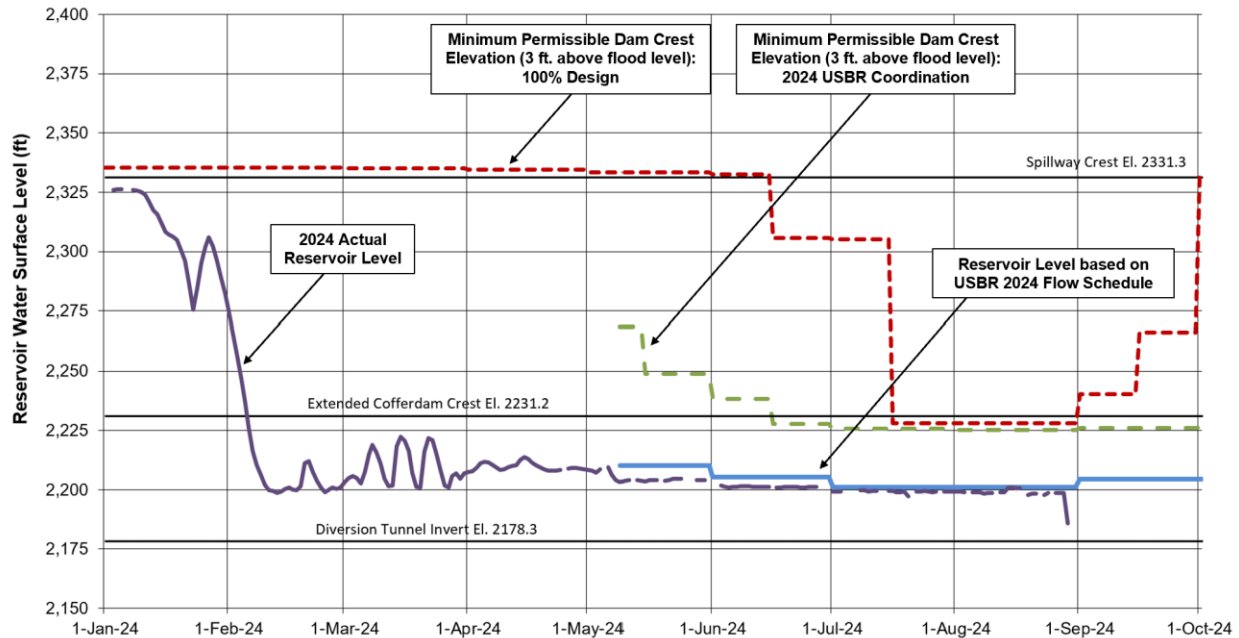


Figure 9: Iron Gate Dam – Minimum Dam Crest Elevations during Removal

5 FINAL BREACH OF IRON GATE COFFERDAM

5.1 Overview

The plan for Iron Gate dam removal involved the dam crest being lowered to the target elevation of the Extended Cofferdam, which is 3 ft (0.9 m) above the 1% probable flood reservoir level for August. The Extended Cofferdam was formed from the remaining portion of the dam embankment and included the historic construction cofferdam. A controlled breach was designed to safely release the residual body of water expected to be present at the time of the final cofferdam breach. The actual breach was successfully completed on August 28, 2024. The controlled breach design and the actual breach are described below and further details are provided in an accompanying paper (Adria et al., 2025).

5.2 Breach Design

To prepare for the controlled breach, a trapezoidal channel was excavated through the Extended Cofferdam adjacent to the right river bank, starting at the downstream end of the dam and terminating at the Historical Cofferdam at the location of the breach plug, as shown on Figure 10. The trapezoidal channel was designed with a base width of 20 ft (6 m) and side slopes graded at 2H:1V or to suit the existing right bank bedrock slope. The breach plug was formed by stabilizing the existing Historical Cofferdam embankment with riprap to reduce the risk of breach flows eroding the embankment materials rapidly and resulting in uncontrolled breach conditions. At the time of breach, the remaining reservoir volume was anticipated to be approximately 516 acre-ft (0.64 million m³), with a maximum depth of 23 ft (7 m) in the residual reservoir water body.

The controlled breach was initiated by excavating a notch through the breach plug to allow the reservoir to discharge into the Extended Cofferdam trapezoidal channel. The dimensions of the notch through the breach plug govern the discharge of the dam breach.

Dam breach analysis was conducted to determine the breach parameters that would result in peak flows within the targeted maximum outflow of approximately 6,000 cfs. Riprap for the breach plug and in the Extended Cofferdam channel were designed to protect the Extended Cofferdam trapezoidal channel from erosion at the estimated peak breach flow condition.

5.3 *Actual Breach*

The final breach of the Iron Gate cofferdam was prepared as designed, and the plug was breached by excavation on August 28, 2024. The breach channel eroded slowly due to the coarse texture of the embankment material and the maximum outflow was well below the target of 6,000 cfs. The successful execution of the final breach is described in Adria et al. (2025).



Figure 10: Final Breach of Iron Gate Cofferdam, August 28, 2024

6 CONCLUSIONS

The Klamath River Renewal Project, the largest dam removal and river restoration project in U.S. history, involved the removal of four hydroelectric dams along the Klamath River in Oregon and California to restore volitional fish passage to historic habitat and spawning grounds. Over 400 stream-miles of salmon habitat have been reconnected, with the first adult chinook salmon returning to their ancient spawning grounds for the first time in over 100 years within weeks of the dams being removed.

KRRC led the way with regulatory and stakeholder engagement throughout the project. All KHSA signatories, and particularly the Yurok Tribe and Karuk Tribe, were key partners in helping move the project forward. Local Tribes have been actively involved in all phases, including the ongoing basin restoration and revegetation efforts, providing extensive indigenous knowledge specific to the Klamath Basin. Knight Piésold was the lead designer for the prime contractor Kiewit, developing innovative designs for the safe decommissioning of the dams.

The Klamath River Renewal Project represents a major step forward in the hydroelectric industry. It demonstrates how the full life cycle of hydroelectric assets can be managed to address broader societal and environmental goals. This promotes the sustainability and resilience of the hydroelectric industry and the watersheds and ecosystems in which it operates.

This project can be considered precedent-setting for the multitude of existing hydroelectric infrastructure assets around the world that are nearing the end of their intended lives. Apprehension related to managing conflicting interests, engineering risk, and the uncertainty of achieving restoration goals can stall decision-making when faced with the decommissioning of obsolete infrastructure assets. This project serves as an example of what can be achieved by a strong committed team as we progress further into this phase of industry and development.

7 ACKNOWLEDGEMENTS

The authors wish to thank the following for the opportunity to work on this ground-breaking project and for their guidance and inputs along the way:

- Klamath River Renewal Corporation (KRRC): Mark Bransom, Laura Hazlett, Oliva Mahony.
- KRRC technical representative: Mort McMillen (McMillen, Inc.).
- KRRC's permitting representatives: Diane Barr, Lisa DeRose (Camas, Inc.).
- Kiewit Infrastructure West Co.: Nick Drury, Erik Esparza, Dan Petersen, Tyler Parker.
- GeoServ, Inc.: James Fitzgerald, Charles Schlumpberger.
- Northwest Hydraulic Consultants, Inc.: Nancy Sims, Todd Bennett, Leonard Joey Howard.
- SWPP Queen, Inc.: Scott Berkebile.

8 REFERENCES

- Adria, D., V. Martin, N. Rong, and K. Wechselberger. 2025. "Dam Breach Analysis used for Designing the Final Breach of the Iron Gate Dam." Canadian Dam Association Annual Conference. Saskatoon, SK. September 29 – October 1.
- AECOM Technical Services Inc., CDM Smith, and River Design Group. 2018. "Definite Plan for the Lower Klamath Project." Prepared for the Klamath River Renewal Corporation.
- Bennett, T., N. Sims, J. Payne, C. Nistor, and A. Shewan. 2025. "Drawdown Modelling of Four Reservoirs on the Klamath River to Support Hydroelectric Facility Decommissioning." Canadian Dam Association Annual Conference. Saskatoon, SK. September 29 – October 1.
- Capucão, C. and K. Wechselberger. 2025. "Optimization of the Iron Gate Dam Historic Diversion Tunnel using CFD Analysis to Support Reservoir Drawdown." Canadian Dam Association Annual Conference. Saskatoon, SK. September 29 – October 1.
- Klamath River Renewal Corporation (KRRC). 2025. <https://klamathrenewal.org/the-project/>.
- Knight Piésold (KP). 2022. "Klamath River Renewal Project – 100% Design Report." Revision 0, May 27, 2022. Ref. No. VA103-640/1-9. Fairfield, CA.
- Otis, B. and C. Capucão. 2025. "Design of Modifications for Reservoir Drawdown, River Diversion and Dam Removal of the Copco No. 1 Dam." Canadian Dam Association Annual Conference. Saskatoon, SK. September 29 – October 1.